A RADIO-FREQUENCY NOISE SURVEY

IN ATLANTA AND VICINITY

A THESIS

Presented to

the Faculty of the Division of Graduate Studies

The Georgia School of Technology

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Electrical Engineering

by

Howard Lindsay McKinley

June, 1948

A RADIO-FREQUENCY NOISE SURVEY

IN ATLANTA AND VICINITY

Approved:

Date Approved by Chairman May 17, 1948

ACKNOWLEDGMENT

I wish to express my sincere appreciation to Professor M. A. Honnell for his valuable aid and guidance in the prosecution of this work.

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A RADIO-FREQUENCY NOISE SURVEY IN ATLANTA AND VICINITY

INTRODUCTION

The purpose of this radio-noise survey was to determine the noise-field strengths at various locations in and near Atlanta and to develop a technique for making these measurements with commercial equipment. A permanent record was obtained by the use of a graphic recorder with a field-strength meter. The measurements were made with a calibrated dipole antenna for both the horizontal and the vertical planes of polarization.

However, before this survey was begun it was necessary to review the previous work in this and allied subjects and to study the techniques developed heretofore. The review revealed that the literature did not contain records of a survey of the type carried on in this project. Yet, the review did reveal some interesting methods which have been used both for making the measurement and for evaluating it. Since the success of the present study did depend in part on the experience of others, it seems desirable to give a summary of the literature before the actual description of the survey.

A RADIO-FREQUENCY NOISE SURVEY IN ATLANTA AND VICINITY

A REVIEW OF THE LITERATURE

It was found that the measurement of radio-noise field intensities presents many problems. Some of these problems are brought about by the complex distribution of noise energy with respect to time. Others are due to the varied distribution of the energy in the frequency spectrum. Still other problems arise when evaluation of one measurement in terms of another, made in a different manner, is attempted.

In general the polarization, direction of propagation, relative phases, and amplitudes of the components of noise fields are subject to variation with reference to time and space. Either or both of two kinds of noise may describe the noise field. One kind, called random noise, is due to a continuous distribution of nondescript radio frequency signals of unrelated phases. The other kind, known as impulse noise, is characterized by peaks of short duration which may exist over wide regions of the spectrum, but the phases are not spread indiscriminately.[1] Less complicated definitions of these kinds of noise may be useful.[2] Random noise may be defined as noise due to an aggregate of

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[1] S. Goldman, "F. M. Noise and Interference", Electronics, Vol. 30, 1941, pp. 37-39.

[2] "Standards on Radio Wave Propagation, Definition of Terms", Proceedings of the Institute of Radio Engineers, Supplement, Vol. 30, 1932, No. 7, part III, p. 4.

a large number of elementary disturbances with random occurrence in time. Impulse noise may be defined as a noise due to a disturbance having an abrupt change and a short duration in time or a succession of non-overlapping disturbances.

The literature on radio-frequency-noise measurements indicates that a knowledge of the total energy throughout the spectrum would not be useful unless its distribution characteristics, in comparatively narrow bands, are known.[3] The value of noise intensity is defined only with reference to a definite band of frequencies. For noise of the random kind, the intensity within a limited frequency band is proportional to the square root of the effective bandwidth. For impulse noise, with impulses non-overlapping, the peak value of the noise field is proportional to the bandwidth and the average value is independent of the bandwidth. For either kind of noise the root-mean-square value is proportional to the square root of the bandwidth. Effective bandwidth is defined as the width of a hypothetical rectangular band-pass filter which will pass the same mean-square value, with the same transfer ratio at some reference frequency (usually mid-band).[4]

There was lack of co-ordination in the early work because techniques and definitions had not been standardized. Most of the measurements made before 1932 were made with regard to the noise effect

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[3] C. M. Burrill, "Progress in the Development of Instruments for Measuring Radio Noise", Proceedings of the Institute of Radio Engineers, Vol. 29, 1941, pp. 433-442.

[4] "Standards on Radio Wave Propagation", p. 4.

on a radio listener. The various methods used had merit, but they did not define the noise field in such a way that the interference with another receiver or receiving system could be evaluated.

One of the methods was recommended as a standard, in the year 1932, by the Joint Co-ordination Committee on Radio Reception of The Edison Electric Institute, The National Electrical Manufacturers Association, and the Radio Manufacturers Association. This committee defined as a primary noise standard, a broadcast frequency sine wave 50 per cent modulated by a 400-cycle sine wave. The unit of measurement of noise voltage was defined as 1 microvolt root-mean-square of the standard wave form and was called the modulated-microvolt.

One measuring technique employed a warbler[5] which was a variable frequency radio-frequency generator. The variation in frequency was accomplished either by revolving condenser plates by means of a mechanical device or by controlling the grid bias of a radio-frequency oscillator by means of variable voltage from a relaxation oscillator.[6] This signal was introduced into the receiver input and the measurer could adjust its amplitude to give a threshold sound condition with the noise signal. The value of the root-mean-square value of the introduced signal was considered the value of sound voltage at the receiver input.

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[5] W. H. Bliss, "New Type of Warbler Tone Generator", Transactions American Institute of Electrical Engineers, Vol. 53, 1934, pp. 547-550.

[6] Ralph Brown, Carl Englund and H. T. Friis, "Radio Transmission Measurements", Proceedings of the Institute of Radio Engineers, Vol. II, 1923, pp. 115-151.

Even though the characteristics of these receivers used for measuring noise were standardized, the method was not entirely satisfactory because the measurement depended on the operator's ability to adjust the variable voltage to the threshold noise condition.

D. O. North has shown the impossibility of evaluating all kinds of noises in terms of interference when a change is made from one bandwidth and response to another bandwidth and response.[7] Since this is true, the measurement may as well be made in microvolts per meter with a specified pass band where the center frequency is used as the reference. The measurement will be more useful if the noise characteristics are noted on an oscilloscope or if a notation is made of its aural characteristics at the time of measurement.

Burrill, in a controlled experiment with a large group of listeners, has shown that the interference is proportional to peak values when impulse noise is present.[9] This condition is more certainly true if the noise is similar to that radiated by automobile ignition systems and is less true if the repetition rate is low, such as one impulse per second.

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[7] D. O. North, "The Absolute Sensitivity of Radio Receivers", R.C.A. Review, Vol. 6, 1942, pp. 332-343.

[8] C. V. Aggers, Dudley Foster, and C. S. Young, "Instruments and Methods for Measuring Radio Noise", Transactions of the American Institute of Electrical Engineers, Vol. 59, 1940, pp. 178-187.

[9] C. M. Burrill, "An Evaluation of Radio-Noise Meter Performance in Terms of Listening Experience", Proceedings of the Institute of Radio Engineers, Vol. 27, 1939, pp. 178-187.

In addition to the preceding investigation, characteristic kinds of sound have been investigated to determine the effect of bandwidth on peak, average, and effective values.[10] The peak values for all kinds of sounds have been found to be higher when the bandwidth is increased. And of all the sounds investigated, the sharp pulse has given the larger peak values regardless of bandwidth.

Studies and experiments such as those mentioned above were instrumental in bringing about a new set of standards which were adopted in 1942. These standards have not as yet been revised, and the accepted method today is to use an amplifier of specified bandwidth. The amplified radio noise signal is fed to a diode detector. The circuit of the detector is also specified in that certain time constants should have a given ratio. For instance in Fig. 1, which is a typical diode detector for noise measurements, the ratio

$$\frac{R_1 C}{RC} = \frac{1}{600}$$

is recommended.[11] This ratio of condenser charging time constant to discharging time constant causes a quasi-peak voltage across the condenser when the noise voltages are rectified. As was mentioned before, the peak and consequently the quasi-peak voltage bears a closer relation to the experienced interference than does average or root-mean-square values.

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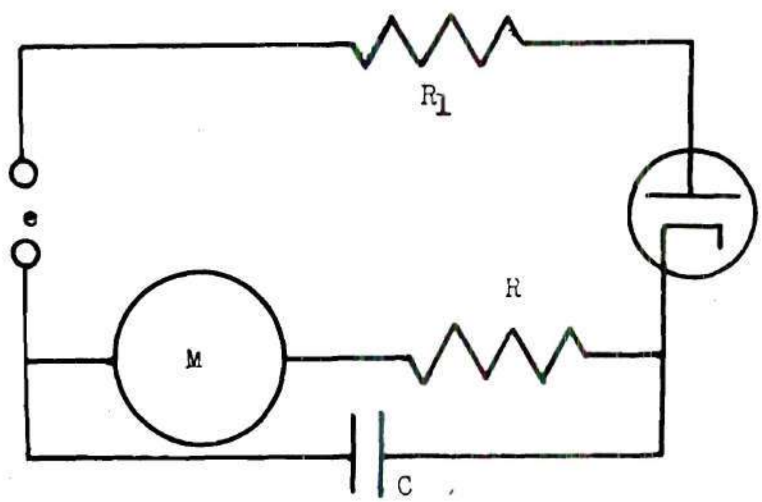
[10] Karl G. Jansky, "An Experimental Investigation of the Characteristics of Certain Kinds of Noises", Proceedings of the Institute of Radio Engineers, Vol. 30, 1942, pp. 473-478.

[11] Aggers, Foster, and Young, op. cit., p. 337.



THE EQUIVALENT CIRCUIT OF THE DETECTOR

FIG. 1.

The circuit of Fig. 1. is an equivalent circuit in which R_1 is an equivalent resistance composed of the diode resistance in series with the output resistance of the amplifier. The condenser is charged during the time the voltage e is larger than the condenser voltage, and the condenser discharges through R during intervals when the condenser voltage is greater than the voltage e. It is evident that if e is a series of pulses where each pulse has a time duration which is long compared to the charging time constant and the repetition rate allows many pulses during the time of the discharging-time constant, the condenser voltage will become near the peak voltage of the pulses. This quasi-peak voltage will not be measured accurately if the pulses are of very short time duration. Kell and Fredendall show a relation between the bandwidth and the shortest pulse which may be measured accurately.[12]

The time constant of the recording or indicating instrument shown in Fig. 1. must be within a specified range. A recording instrument with a very short time constant would be expensive and a poor risk in a portable field-strength meter. On the other hand, a meter movement with long time constant requires unreasonable values of R and C. It is desirable to have the over-all time constant controlled by circuit values rather than by the instrument. This result may be accomplished by making the condenser-charging time constant short and the discharging time constant long as compared to the meter time constant. Meter time constants rang-

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[12] R. G. Kell and G. L. Fredendall, "Selective Side-Band Transmission in Television", R.C.A. Review, Vol. 4, 1940, pp. 425-440.

ing between 20 and 400 milliseconds have been found suitable.[13]

In addition to the foregoing, the literature indicates measurements have been made on radio-noise generated by atmospheric disturbances, electrical machinery, automobiles, power transmission lines, and power distribution lines. Many of these measurements have been made in attempting to locate interference sources and to reduce the radiated interference at the source.[14] Noise fields near a 132-kilovolt transmission line have been found to average 20 decibels above 1 microvolt per meter.[15] Aeroplane and automobile noise-fields have been investigated and methods for reducing the interference have been developed.[16]

The radio interference due to atmospherics, commonly known as static, has been investigated over long periods of time. Automatic recordings of static fields showing magnitude, direction, and polarity have been made.[17] Noise fields caused by local thunder storms 1 mile

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[13] W. N. Goodwin, Discussion, "Instruments and Methods of Measuring Radio Noise", Transactions American Institute of Electrical Engineers, Vol. 59, 1940, pp. 178-187.

[14] A. J. Gill and S. Whitehad, "Electrical Interference with Radio Reception", Journal of the Institute of Electrical Engineers, Vol. 83, 1938, pp. 345-594.

[15] Ibid.

[16] R. W. George, "Field Strength of Motor Car Ignition Between 40 and 450 Megacycles", Proceedings of the Institute of Radio Engineers, Vol. 28, 1938, pp. 409-412.

[17] F. E. Lutkin, "Directional Recording of Radio Atmospherics", Journal of the Institute of Electrical Engineers, Vol. 82, 1938, pp. 289-302.

distant have shown interference levels 85 decibels above 1 microvolt per meter, while at 10 miles the field strength may have peaks of 65 decibels above 1 microvolt per meter.[18]

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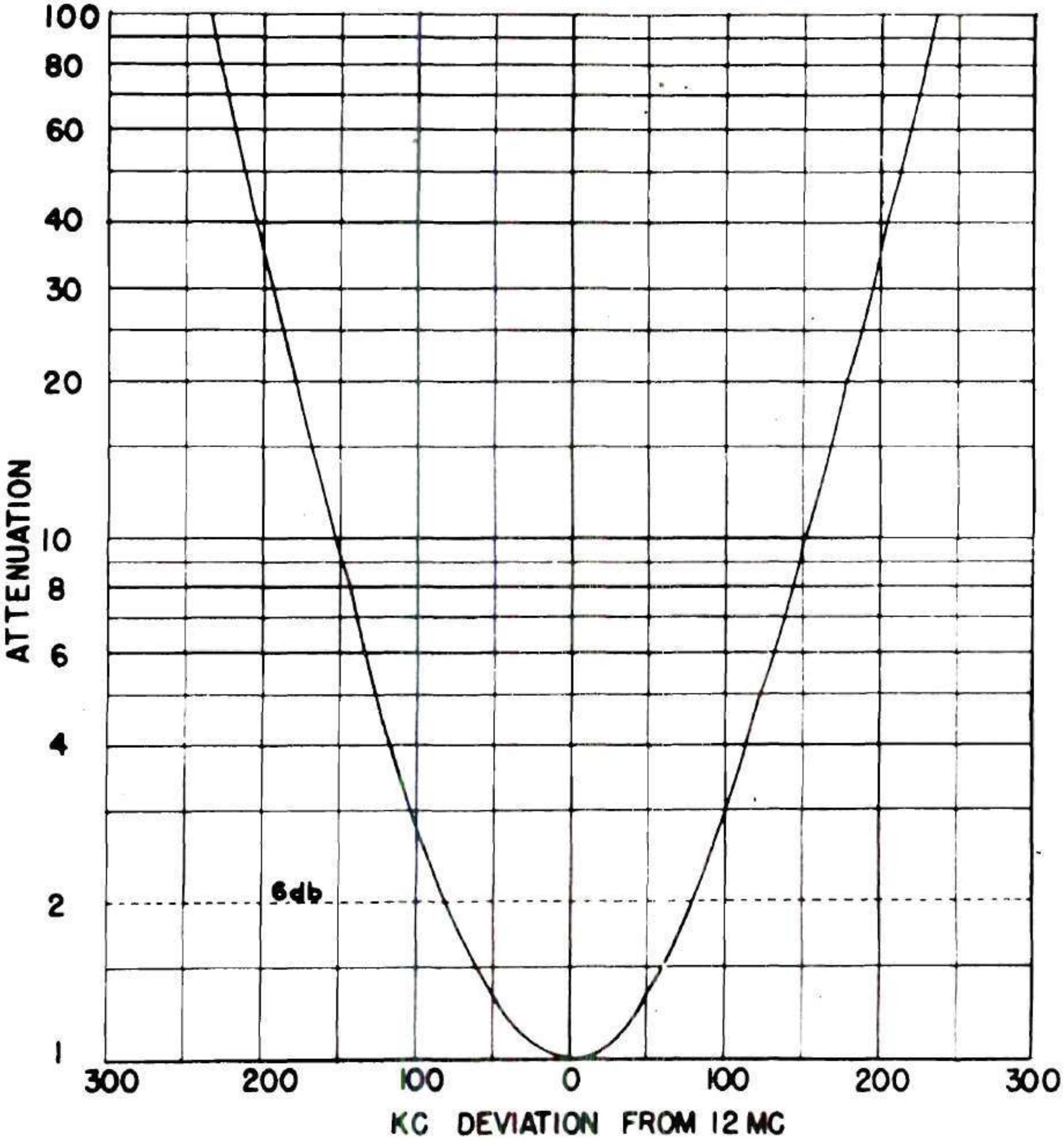
[18] J. P. Schofer and W. M. Goodall, "Peak Field Strength of Atmospherics Due to Local Thunderstorms at 150 Megacycles", Proceedings of the Institute of Radio Engineers, Vol. 27, 1939, pp. 202-207.

EQUIPMENT

The equipment used in this survey consists of a field-strength meter manufactured by the Measurements Corporation, UHF Radio Noise and Field Strength Meter Model 58 and a graphic instrument manufactured by the Esterline-Angus Company, Inc., which is a 0-5 Milliammeter Model AW, and a portable antenna.

The field-strength meter is a five-band superheterodyne with its gain standardized at a fixed value. Indications are readable directly on a calibrated 0- to 100-microvolt meter, with provisions for headphone monitoring and recorder connections. To insure accuracy the instrument possesses a self-contained calibration circuit, a pre-selector stage having a high image rejection, a balanced-to-ground attenuator network and provisions for obtaining peak or average measurements of pulse or modulation voltages. This set uses a 12-megacycle intermediate frequency. The intermediate-frequency selectivity curve is shown in Fig. 2.

The design of the self-contained calibration circuit is based on the fact that pure shot noise exists in the absence of space charge within a vacuum tube. The shot noise is directly proportional to the direct-current plate current, and it is distributed uniformly throughout the frequency spectrum. Consequently, tuning controls are not needed in this signal source and a direct-current milliammeter may be used for adjusting the amplitude to some prescribed value. The time constant of the detector circuit as shown on page 7 has the ratio:



INTERMEDIATE-FREQUENCY SELECTIVITY CURVE

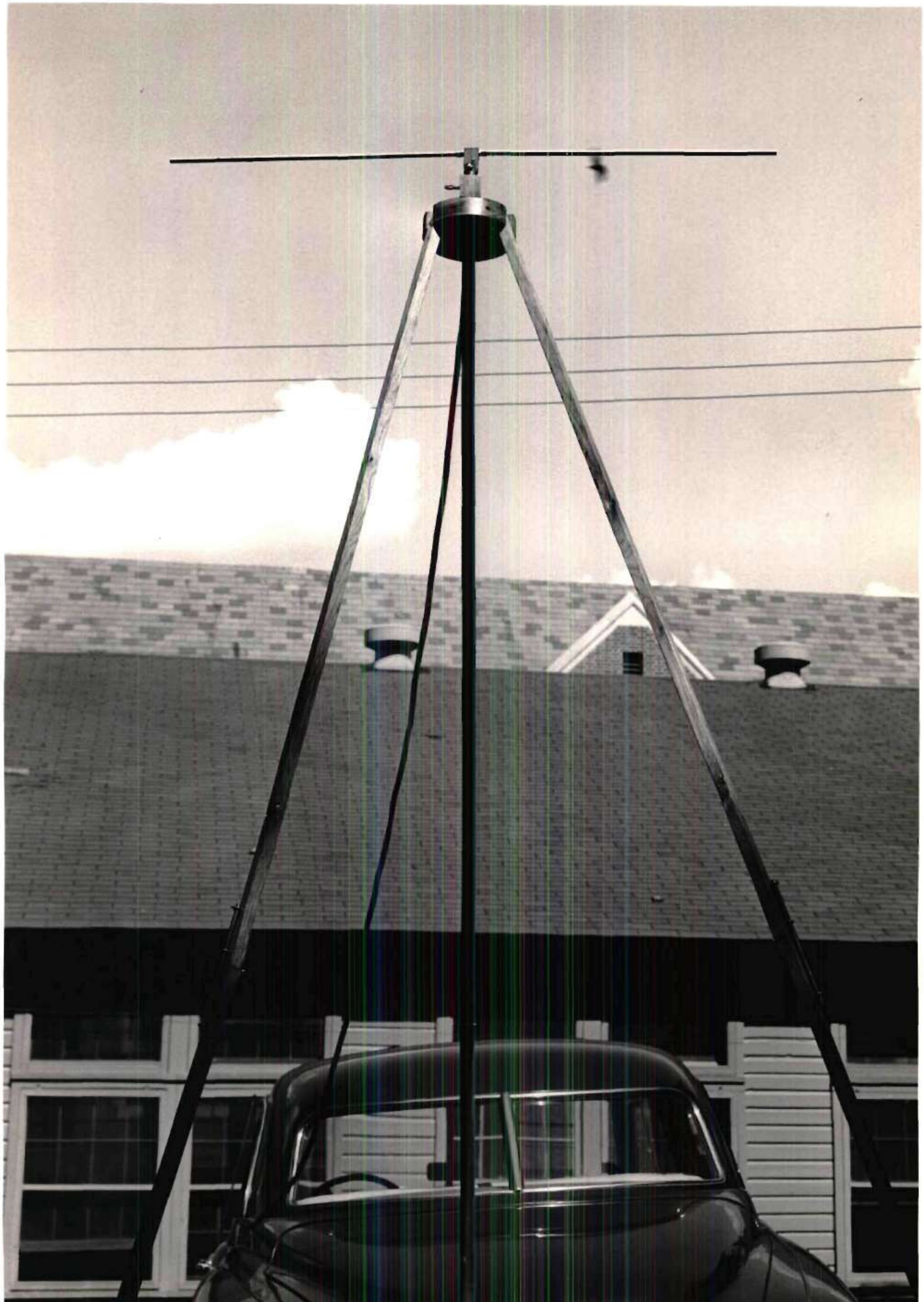
FIGURE 2.

$$\frac{\text{1 millisecond, charging}}{\text{600 milliseconds, discharging}}$$

The graphic meter has a 5-milliampere direct-current movement, an inking stylus, a spring-wound chart drive, and provisions for varying the chart speed. Since the recorder should be level, or nearly so, a wooden platform supports the recorder and the field-strength meter on the back seat of the automobile. This is shown in Fig. 3. The remaining equipment consists of a storage battery, an antenna, a portable antenna tripod, and connecting cables. The antenna used consists of a center insulating section with threaded posts and two sets of two rods each. Either set of rods forms a half-wave doublet antenna when screwed on to the posts in the center section. The antenna and tripod are shown in Fig. 4.

The following section outlines the methods used in making the noise-field measurements.

PHOTOGRAPH OF THE RECORDING EQUIPMENT FIGURE 3.



PHOTOGRAPH OF THE PORTABLE ANTENNA FIGURE 4.

OPERATING TECHNIQUE

The plan followed in the use of the equipment was to make a radio-frequency-noise survey on frequencies near the frequency-modulation band and also near the bands used for portable mobile purposes. The two frequencies, 90 megacycles and 130 megacycles, were selected. Various locations in and near Atlanta were chosen as measuring sites, the choice requiring some study, since it was desirable to get a representative cross-section of the radio noises. Sites in commercial trading areas, predominately industrial areas, and strictly residential areas were picked.

After one of the chosen sites was reached, the antenna was assembled, erected, and connected to the field-strength meter, which was carefully tuned to 90 megacycles and calibrated according to the operating instructions. The calibration was checked periodically during the measurement. At the beginning of each horizontally polarized field measurement the antenna was rotated for maximum noise deflection. However, in many instances, where the greater part of the noise field was due to automobiles the antenna was left broadside toward the nearest automobile traffic.

The vertically-polarized field at 90 megacycles was recorded next. Each measurement was made over a time interval ranging from 5 to 10 minutes, and the chart speed was 3 inches per minute. Various marks and symbols were penciled on the chart during the measurement intervals to indicate change in noise characteristics when noticed in the headphones. A schedule of notes, kept on a separate pad, were helpful during the analysis of the charts.

The 130-megacycle measurements were made in the same manner as those at 90 megacycles.

During these measurements it was found that automobiles created a major part of the noise field in many of the locations. However, there seemed to be no correlation index whereby the field caused by any one automobile could be estimated, although it was apparent that higher motor speeds gave greater field strengths.

It seemed that the investigation of the radiation from one automobile at these frequencies could yield useful information, and such an investigation was made. Measurements were made in a rural location away from other noise sources. The equipment was set up on level terrain, and stakes put at distances of 25, 50, 100, and 150 feet from the antenna. A throttle stop on the automobile assured constant motor speed during measurement. Measurements were made with the front, side, and back of the car toward the antenna. The maximum deflection, with horizontal polarization, occurred in all cases with the antenna broadside toward the automobile.

ANALYSIS OF THE DATA

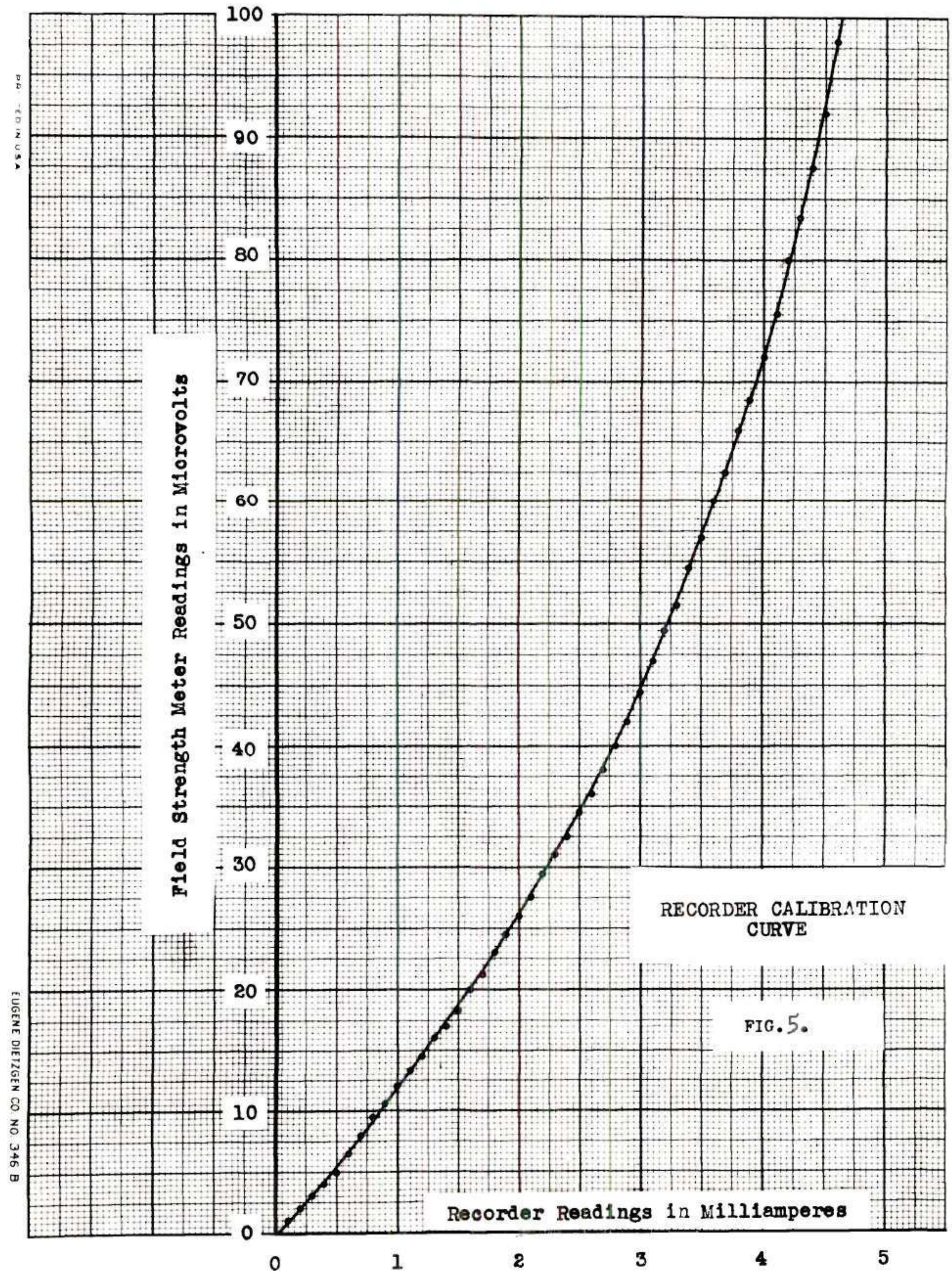
Before an analysis of the charts resulting from the operations just described was made, it was necessary to obtain a relation between the microvolt-meter deflections and the deflections of the recording milliammeter. This relationship is shown in Fig. 5. Data were taken for the plot of the graph in Fig. 5. by feeding the variable output of a microvolter to the antenna terminals of the field-strength meter. The inking stylus and chart drive were operating normally at this time. The microvoltmeter deflections were recorded for each 0.1 milliampere.

Since the graph of Fig. 5. converts the chart recordings in milliamperes to the instrument indication in microvolts, the field strength at the antenna may be calculated by the method outlined in the manual of operating instructions furnished with the field-strength meter. The general form of the equation for calculating the field strength at the antenna from the meter indication is

$$\text{Microvolts per meter} = C \, \frac{\text{Microvoltmeter indication}}{\text{Effective height of antenna in meters}}$$

where C is a constant which has the same value for all frequencies inside any one band. The constant corrects for line losses, matching losses, and the fixed gain of the amplifier, which is determined in the calibration process. The effective height of a half-wave doublet antenna is

$$\text{Effective height in meters} = \frac{\text{Wave length in meters}}{\pi} .$$


100
90
80
70
60
50
40
30
20
10
0
Field Strength Meter Readings in Microvolts
RECORDER CALIBRATION CURVE
FIG. 5.
Recorder Readings in Milliamperes
0
1
2
3
4
5
EUGENE DIETZGEN CO. NO. 346 B

By use of these equations and the calibration curve, the field strength may be calculated for any instant of time recorded on the charts. However, a study of the charts shows that the noise field in many locations varies rapidly with time. This variation is to be expected, as much of the noise field is due to automobiles and electrical apparatus. The noise fields in various locations were compared on a basis of amplitude as a function of time in per cent as aural sounds are often compared. These fields were plotted in decibels above 1 microvolt per meter as a function of the percentage of the total recorded time. Since the chart moved at constant speed, the ratio

$$\frac{\text{Inches of chart inked above an arbitrary value of milliamperes}}{\text{Total inches of chart}}$$

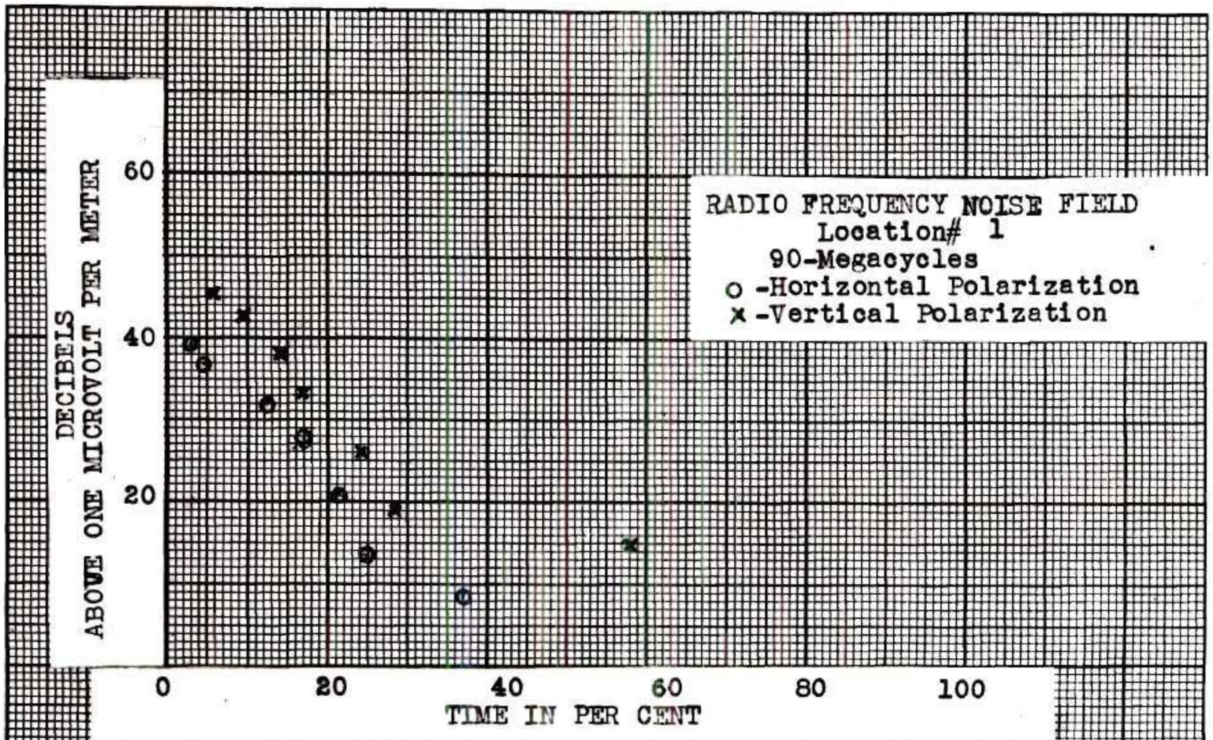
expressed in percentage is equal to the percentage of time during which the noise-field voltage is above that corresponding to the arbitrary value of milliamperes. Making these linear measurements with an ordinary rule or tape would have been an extremely tedious task. An instrument known as a map measure was used to simplify this task.

A study of the charts indicated that the recorded currents shown in Column 1, Table I, page 44 would be satisfactory. Column 2, Table I was taken from the graph of Fig. 5, and the field strengths which are shown in the remaining columns were calculated in accordance with the information given on page 18. The information for each location was tabulated and these tables are included in the Appendix. The graphs of Figs. 6 through 17 were drawn for noise field comparison purposes. If the radio-frequency noise consisted of single pulses or of a few pulses very close in time with a long interval of elapsed time before another pulse or train of pulses, the chart could not be analyzed as above. The reason the above method could not be used is that if the pulse time is short the inked trace is a vertical line. This could have been overcome by using a very fast chart speed which would have given pulse widths large in comparison to the width of the line drawn by the stylus. A suitable comparison of such fields could be made by counting the pulses which have amplitudes exceeding arbitrary levels and by graphing these amplitudes as functions of percentages of the total number of pulses in a given time period as shown in Fig. 17.

One type of noise field encountered at two locations during this survey could not be analyzed by either of the methods outlined above. These fields were strong, but the field strength varied only slightly. However, in keeping with the above methods, these fields of constant strength could be described as being equal to or above some value 100 per cent of the time. Sections of the charts are shown on pages 60 and 61.

Fig. 20 shows the area in which the survey was made. The center of the circles are the sites where the noise fields were measured, and the numbers within the circles are the location numbers which identify the corresponding charts, graphs, and tables.

A comparison of the graphs of Figs. 6, 7, 8, and 9 shows that each of these locations had noise of from 40 to 60 decibels above 1 microvolt per meter for low percentages of time. The high noise levels in Figs. 8 and 9 are maintained over higher percentages of time, and this fact is evidently the reason that these two locations seemed more noisy than


RADIO FREQUENCY NOISE FIELD
Location# 1
90-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

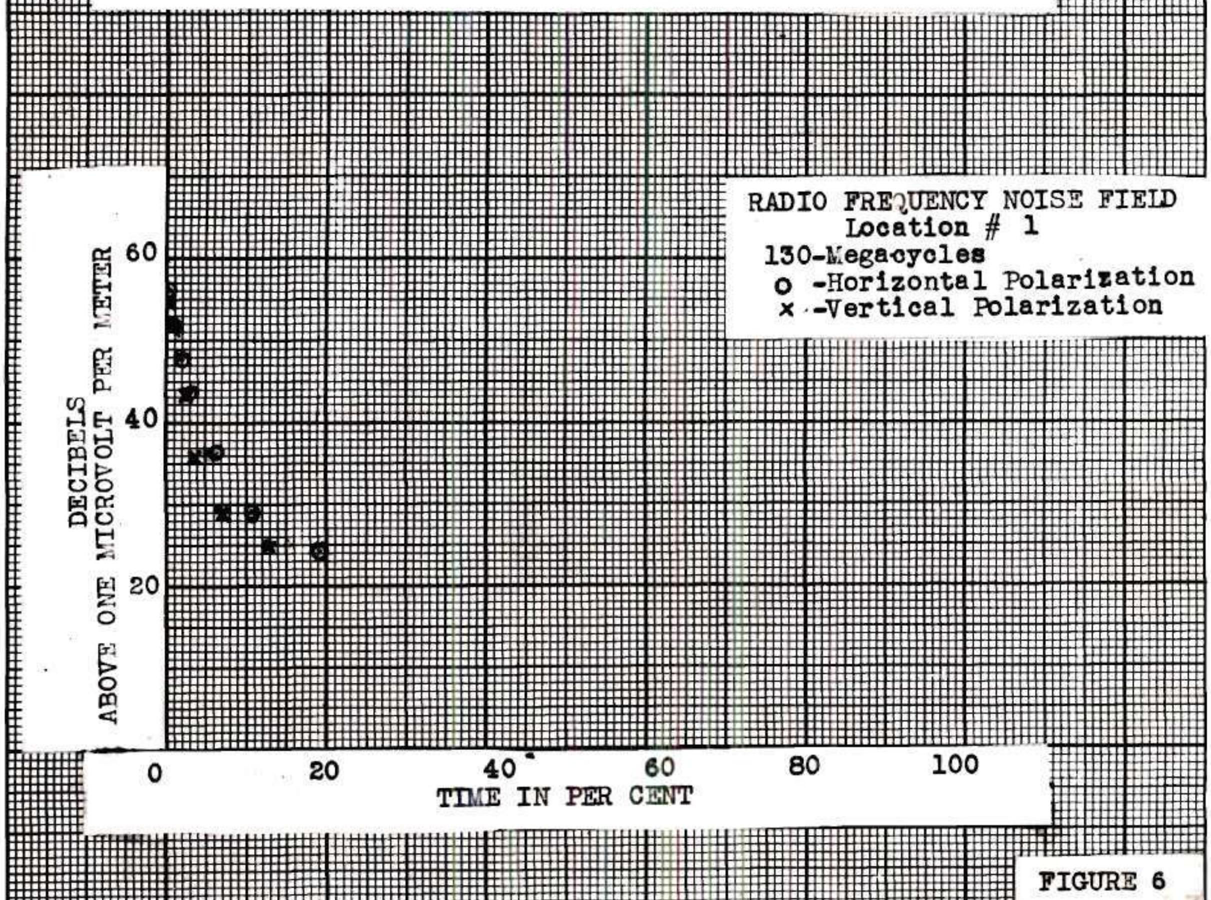
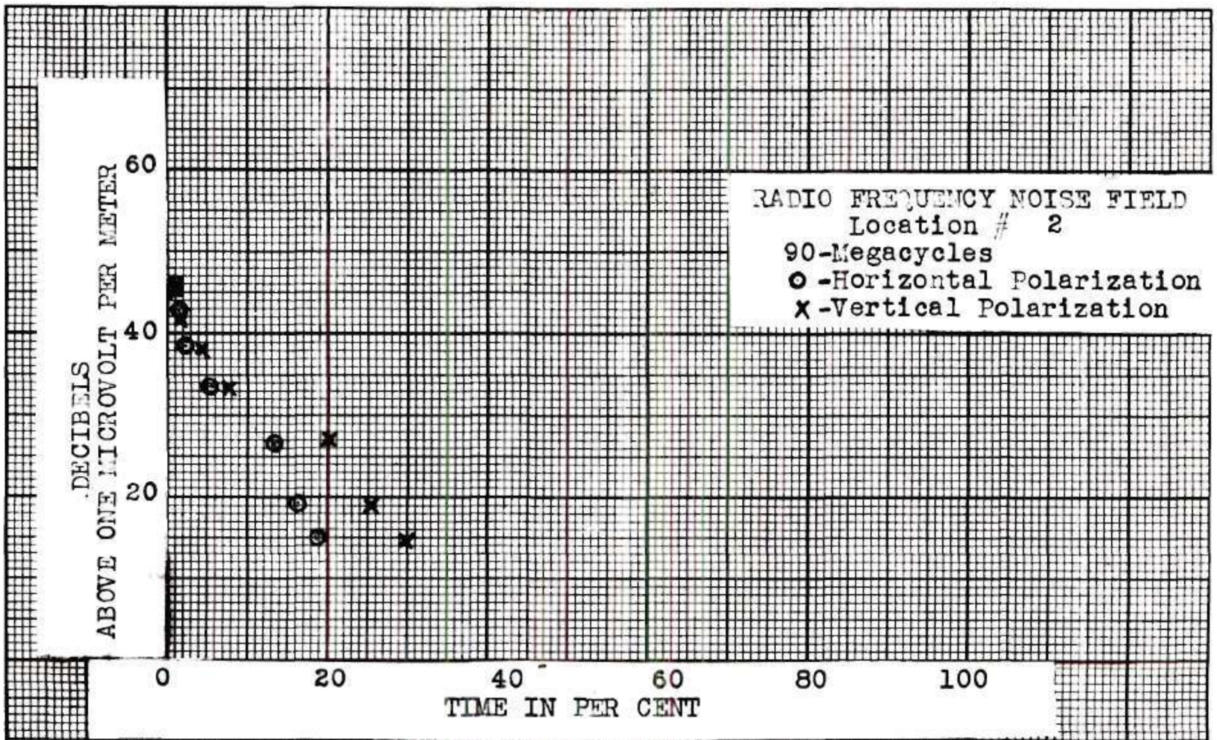

RADIO FREQUENCY NOISE FIELD
Location # 1
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 6


RADIO FREQUENCY NOISE FIELD
Location # 2
90-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

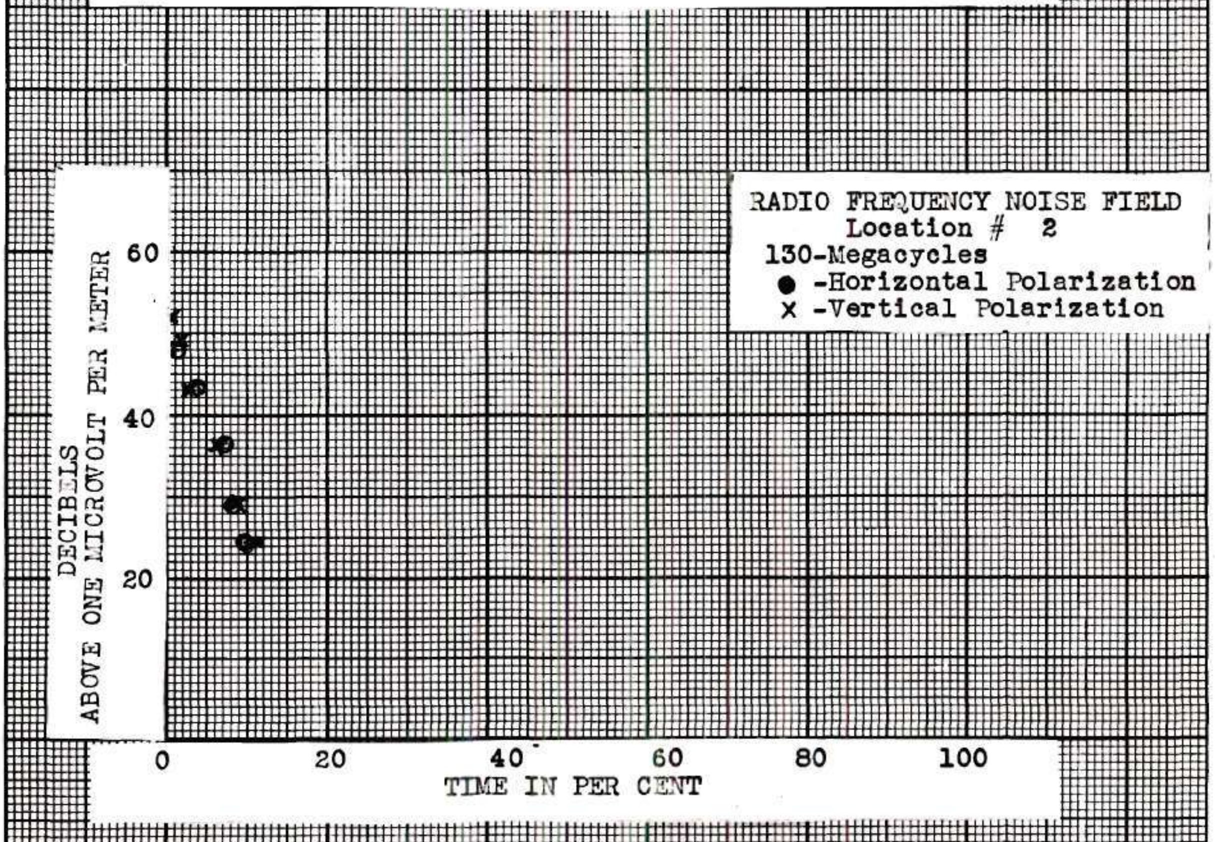
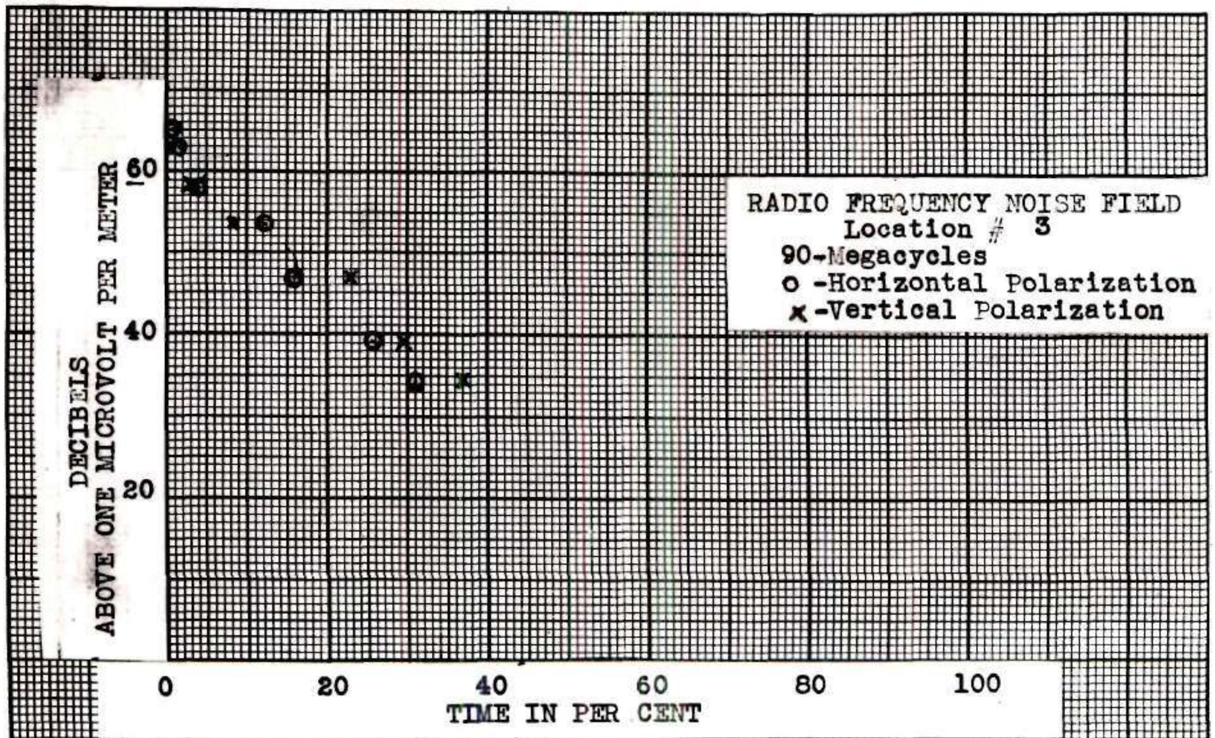

RADIO FREQUENCY NOISE FIELD
Location # 2
130-Megacycles
● -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 7


RADIO FREQUENCY NOISE FIELD
Location # 3
90-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

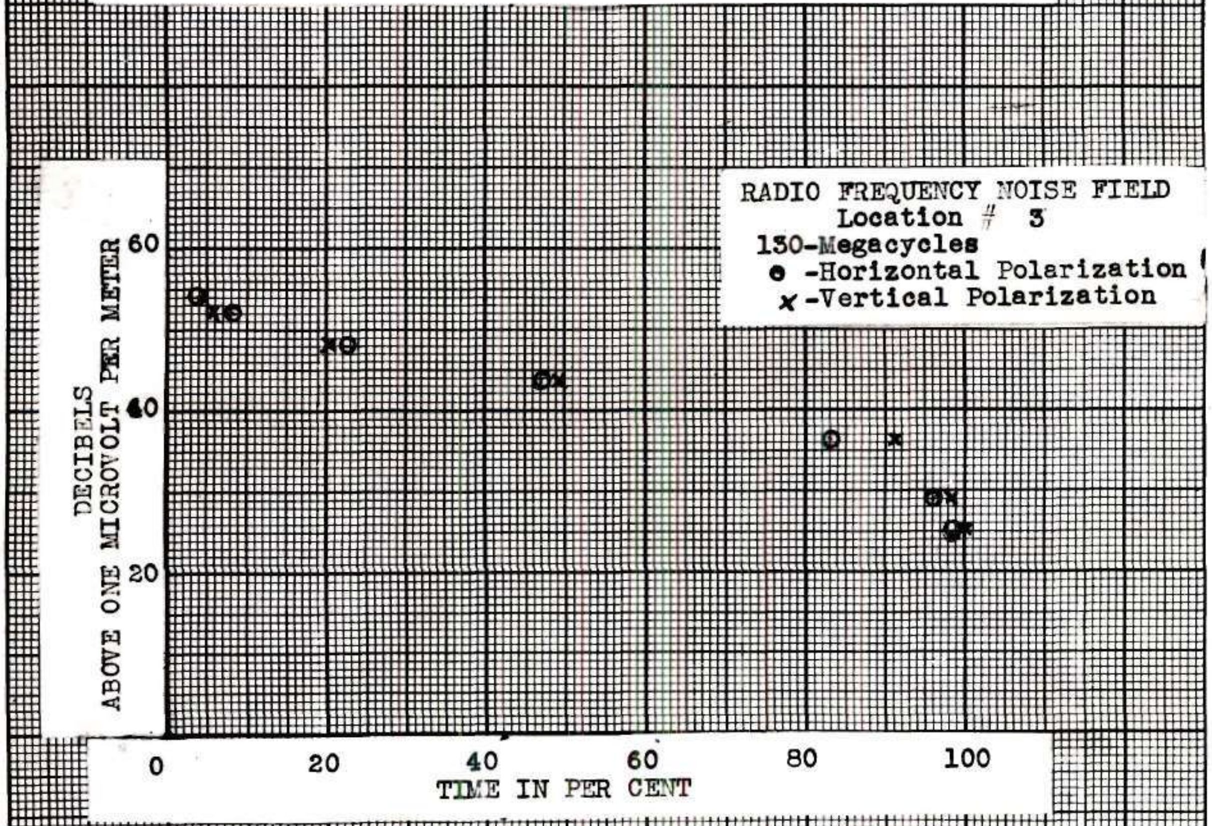

RADIO FREQUENCY NOISE FIELD
Location # 3
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 8

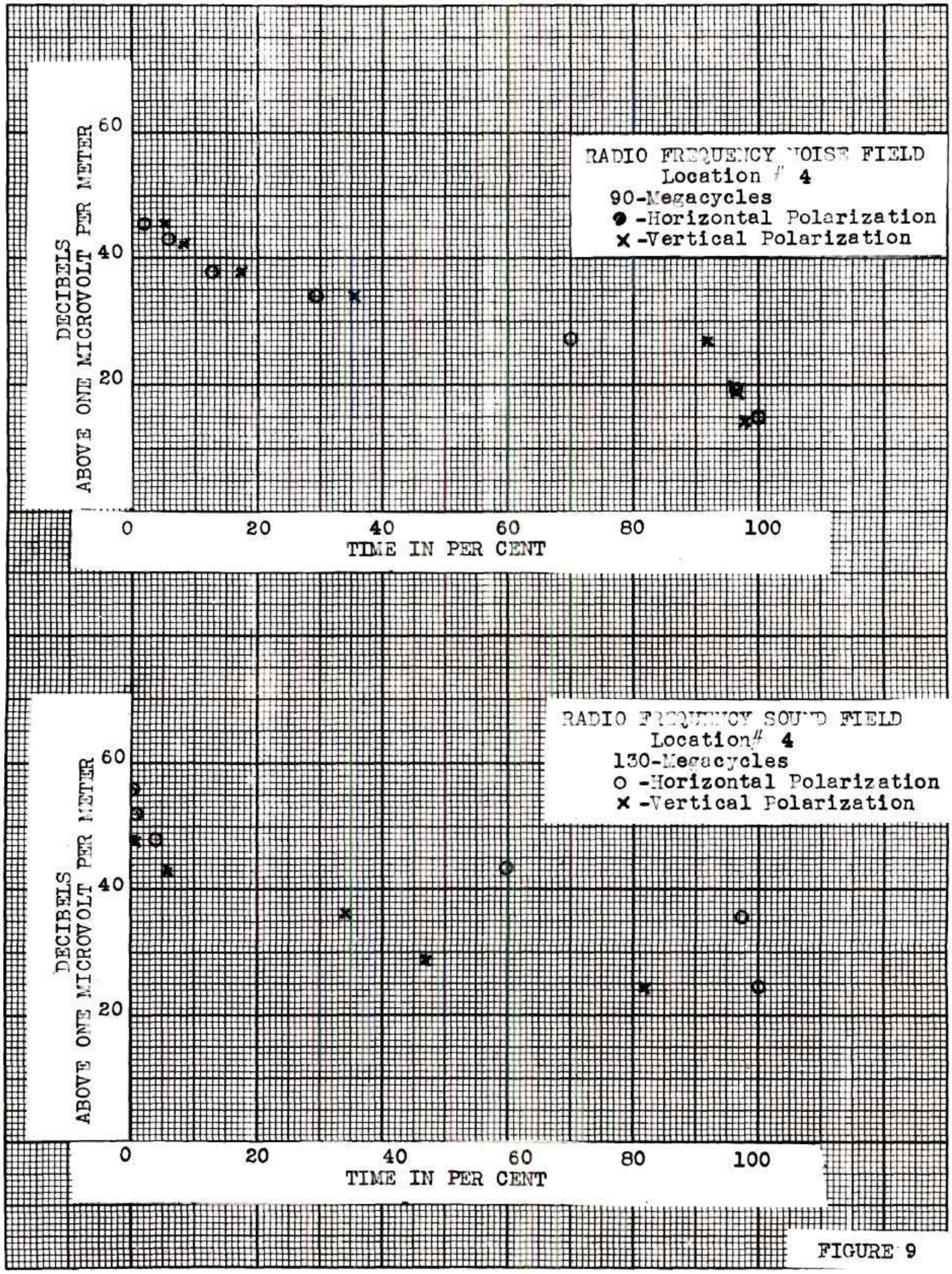
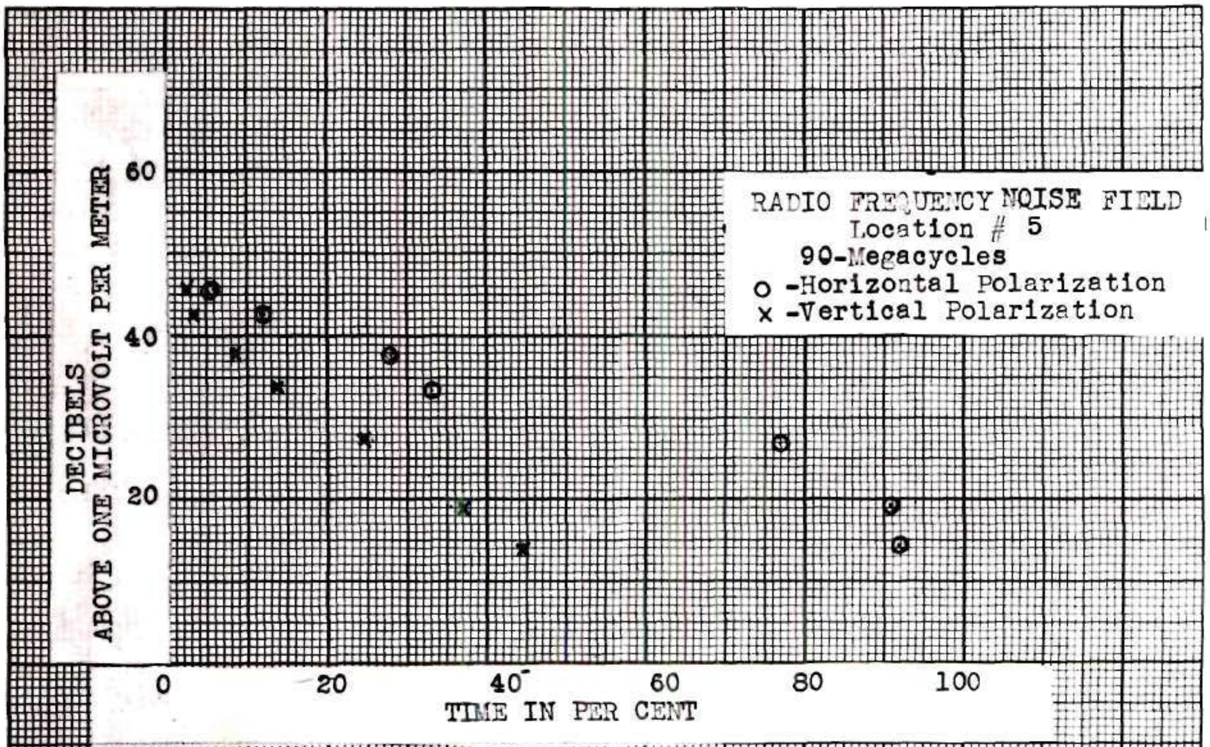

RADIO FREQUENCY NOISE FIELD
Location # 4
90-Megacycles
-Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT
RADIO FREQUENCY SOUND FIELD
Location# 4
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 9

the locations of Figs. 6 and 7. The notes made during the period of listening at these locations describe locations 1 and 2, corresponding to Figs. 6 and 7, as having barely perceptible noise. On the other hand, the notes describe locations 3 and 4, corresponding to Figs. 8 and 9, as being very noisy.

When the horizontal field strengths of Figs. 10 and 11 are compared, it is seen that they are distributed in time in a similar manner and that they are of about equal amplitude. However, these noises sounded very different to the ear. The noise corresponding to Fig. 10 was composed of many rapid pulses, which were caused for the most part by automobiles, and had a roaring sound. On the other hand the noise graphed in Fig. 11 was a rapidly changing musical sound, both in tone and volume. A similar noise was noticed near high-voltage transformer banks at other locations. However, there is no high-voltage installation near location 6 which is graphed in Fig. 11. This source could have been located by a diligent search with the field-strength meter, though the exact location of the noise sources was not considered a part of this survey.

The noise-field graphs of Figs. 12 and 13 show relatively high amplitude distributed throughout time, indicating that these locations were very noisy. The location corresponding to Fig. 12 had high automobile noise as well as sharp pulses which were evidently caused by electrical apparatus in the large printing plant nearby. Figs. 14, 15, and 16 are graphs of noise fields at locations where the noise was not high and where most of that measured was due to light automobile traffic. The noise-field strengths graphed in Fig. 17 were measured at location 12 near a large shirt factory. The noise was of a pulse nature with differ-


RADIO FREQUENCY NOISE FIELD
Location # 5
90-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
20
40
60
0
20
40
60
80
100
TIME IN PER CENT

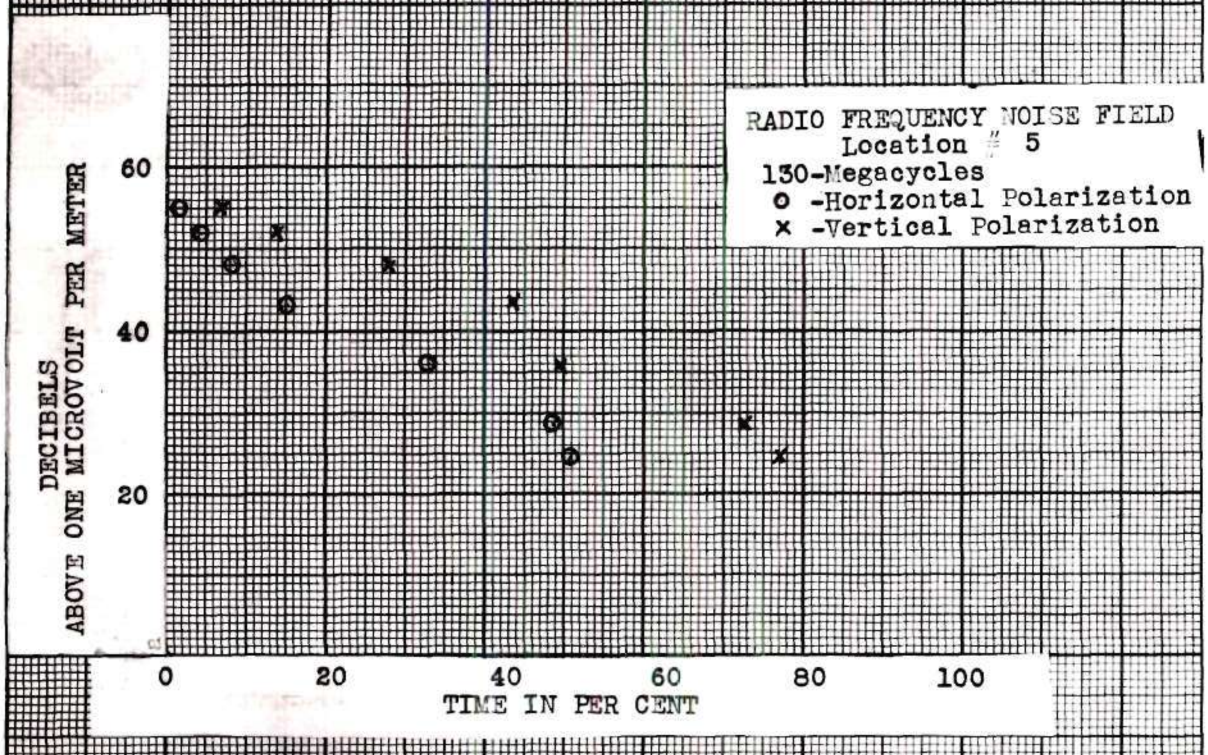
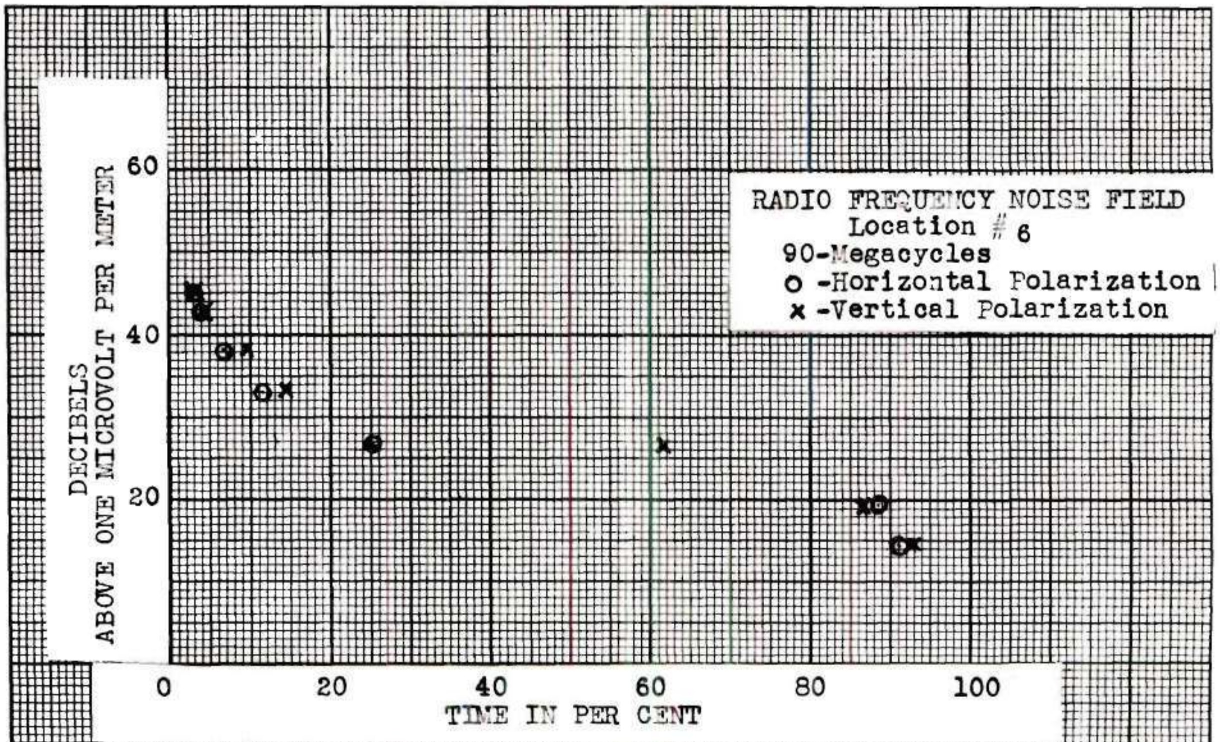

RADIO FREQUENCY NOISE FIELD
Location # 5
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
20
40
60
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 10


RADIO FREQUENCY NOISE FIELD
Location # 6
90-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

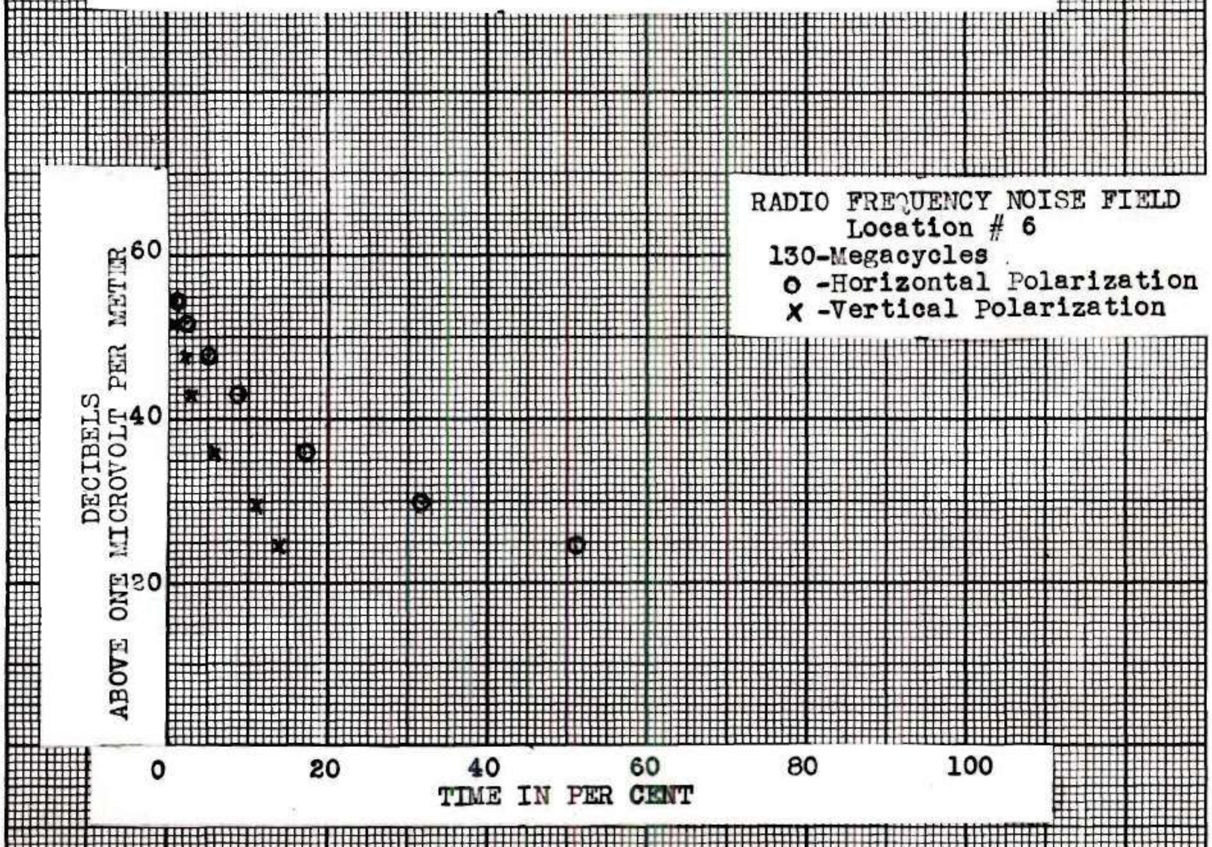

RADIO FREQUENCY NOISE FIELD
Location # 6
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 11

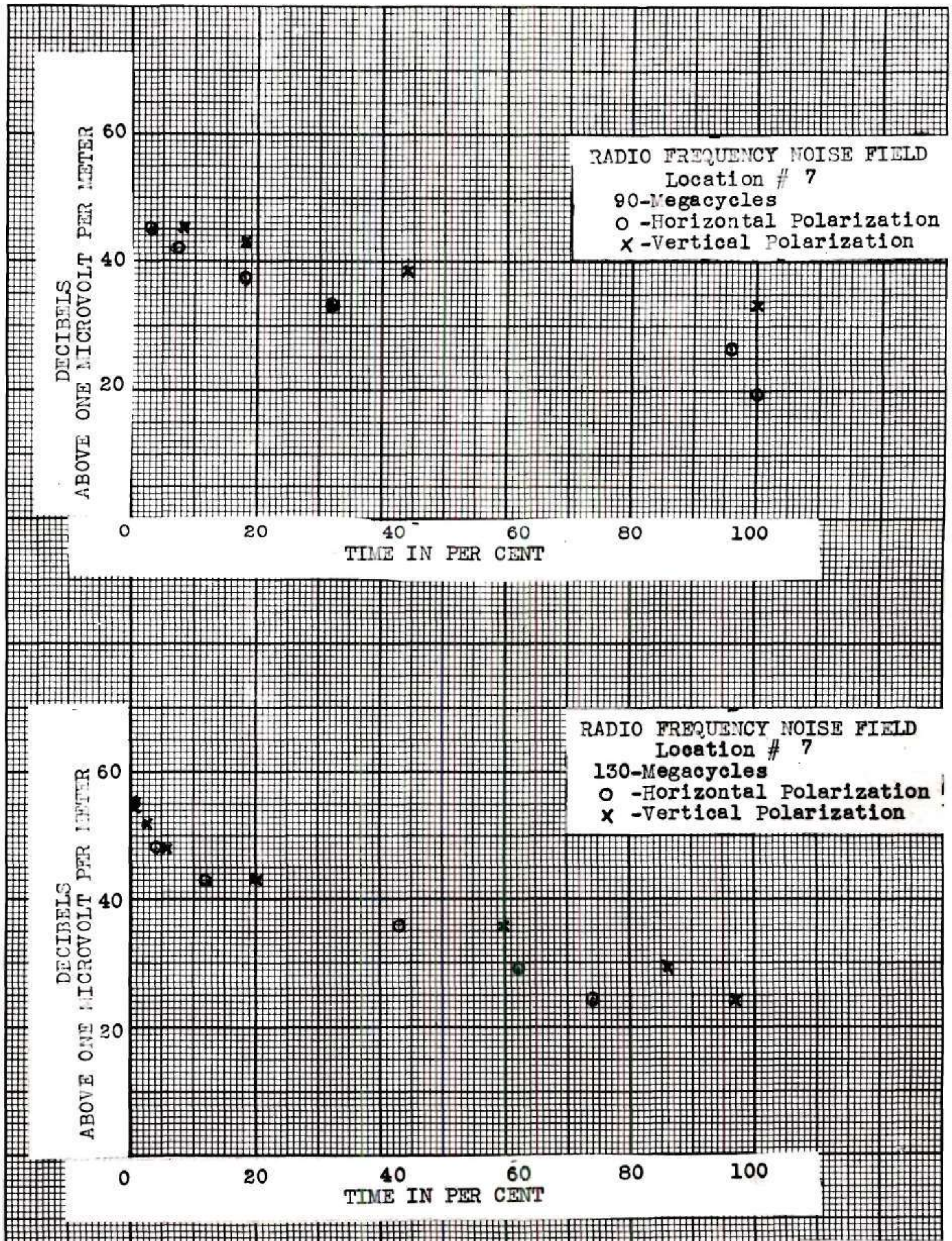
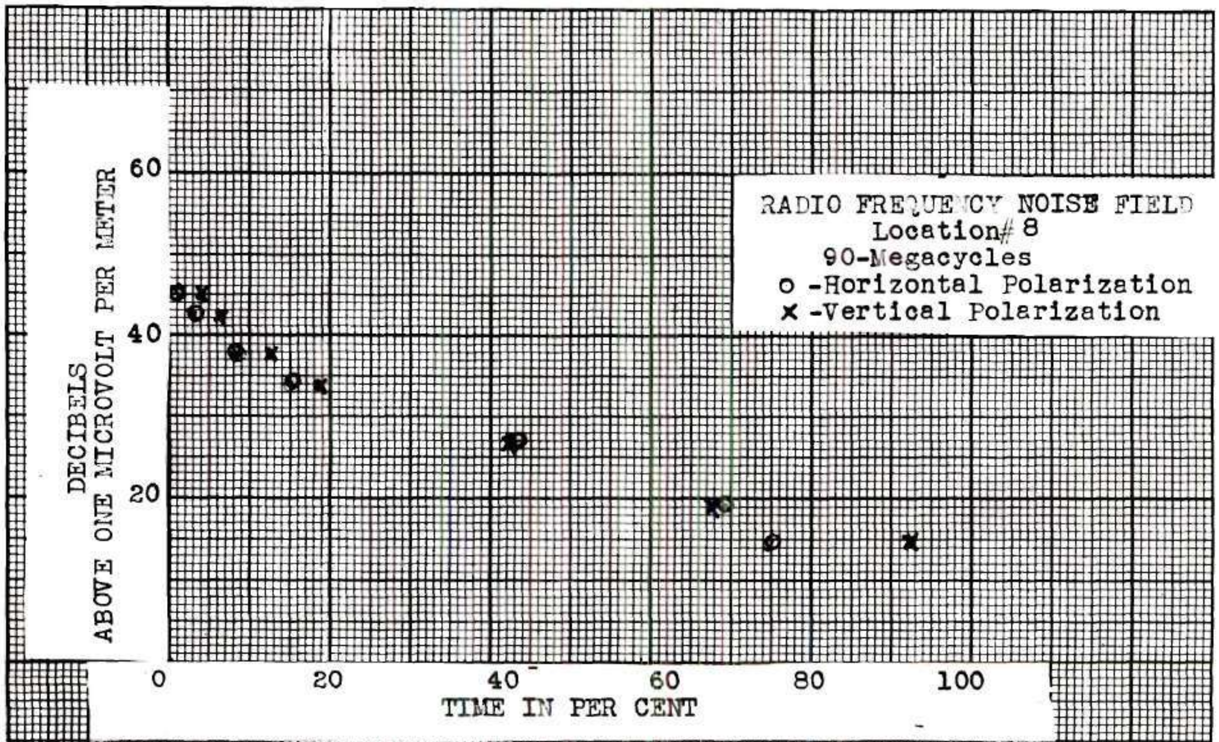

RADIO FREQUENCY NOISE FIELD
Location # 7
90-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT
RADIO FREQUENCY NOISE FIELD
Location # 7
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 12


RADIO FREQUENCY NOISE FIELD
Location# 8
90-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

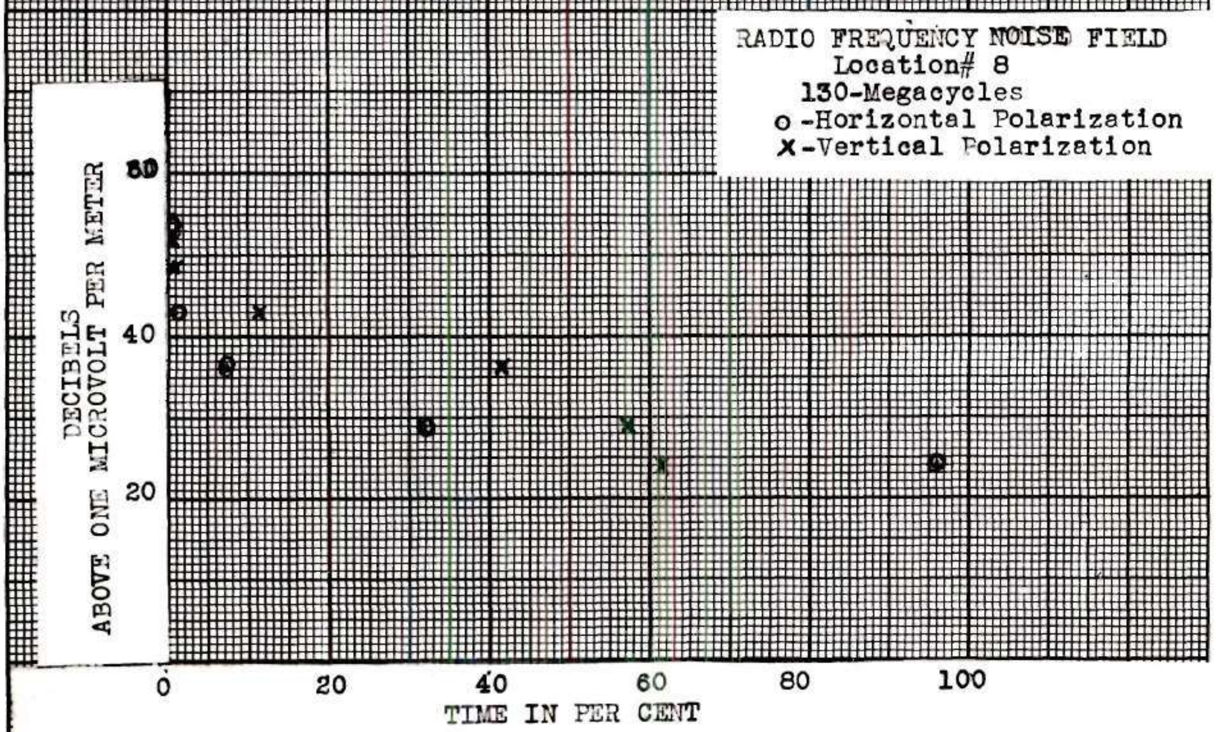
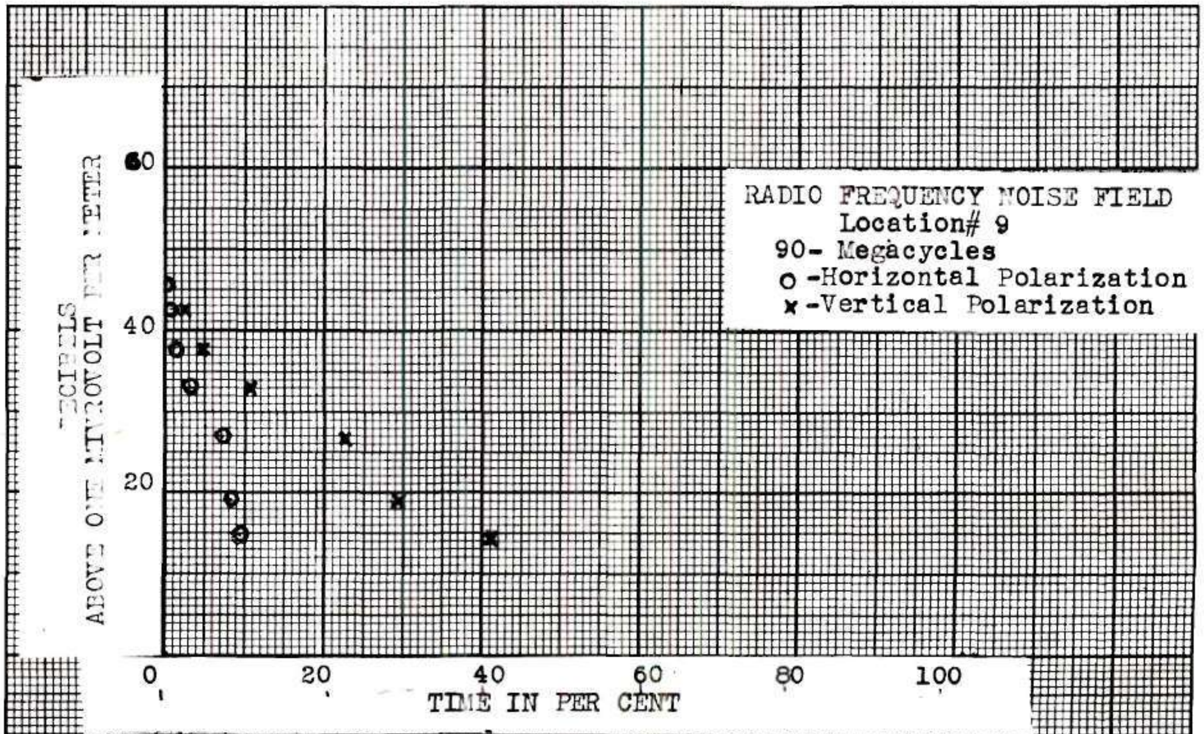

RADIO FREQUENCY NOISE FIELD
Location# 8
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 13


RADIO FREQUENCY NOISE FIELD
Location# 9
90- Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

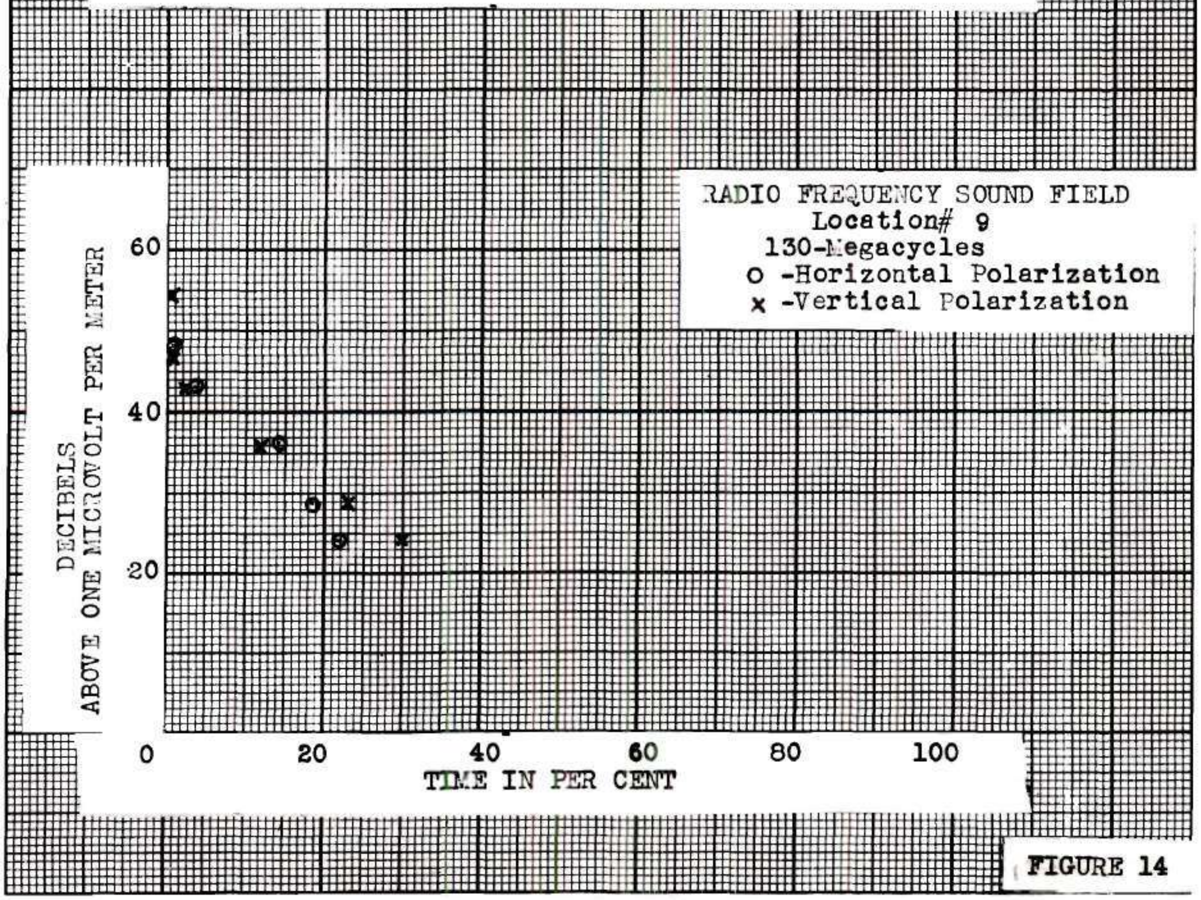
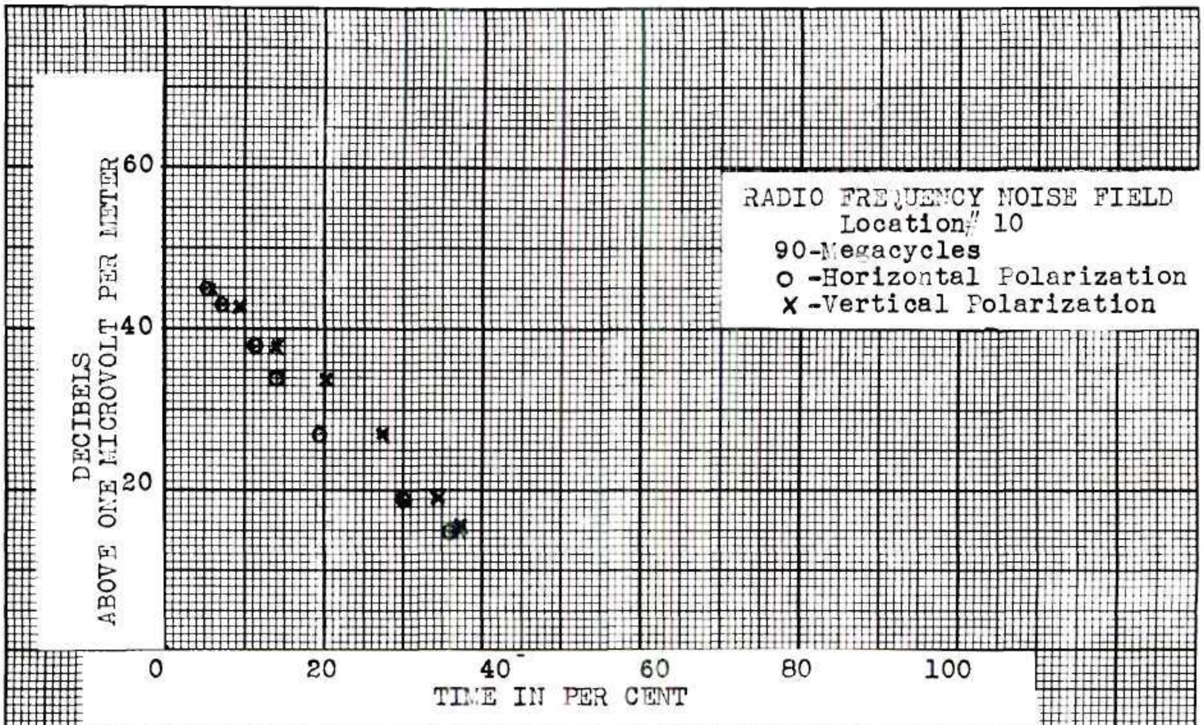

RADIO FREQUENCY SOUND FIELD
Location# 9
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 14


RADIO FREQUENCY NOISE FIELD
Location # 10
90-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

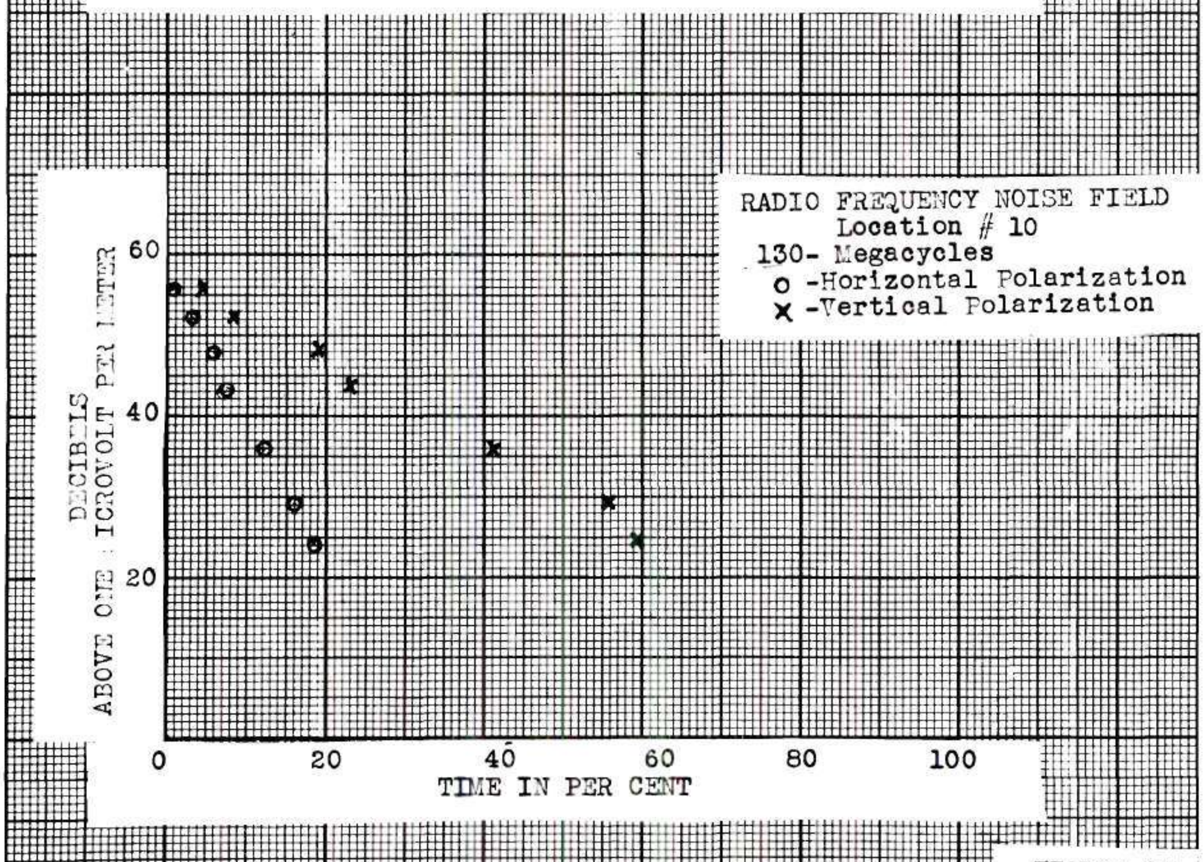

RADIO FREQUENCY NOISE FIELD
Location # 10
130- Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 15

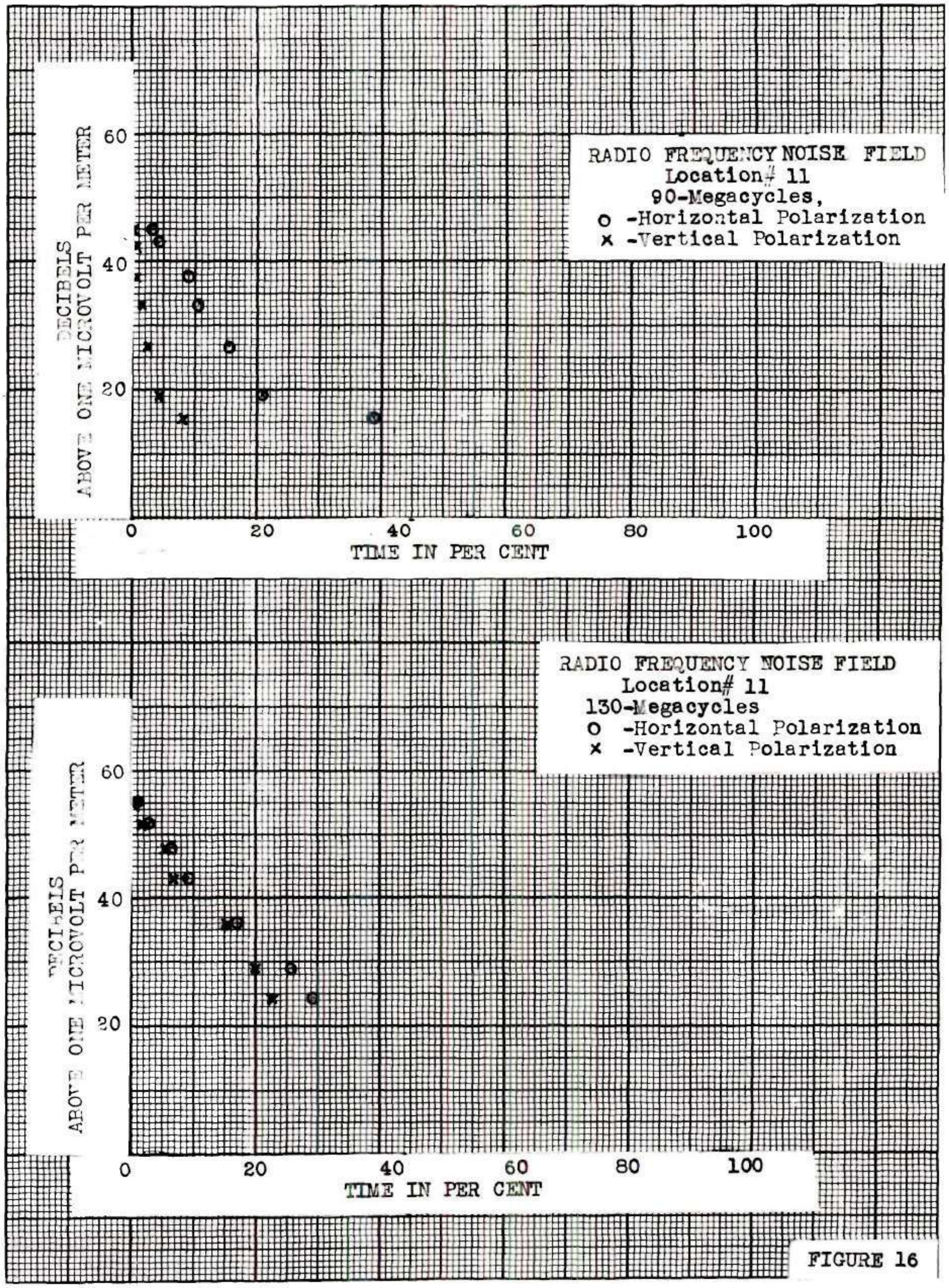

RADIO FREQUENCY NOISE FIELD
Location# 11
90-Megacycles,
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT
RADIO FREQUENCY NOISE FIELD
Location# 11
130-Megacycles
o -Horizontal Polarization
x -Vertical Polarization
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
20
40
60
80
100
TIME IN PER CENT

FIGURE 16

ent amplitudes, and the pulses did not seem to be distributed in a definite pattern with respect to time.

Figs. 18 and 19 are graphs of the noise-field as a function of distance caused by one automobile. Table II, in the Appendix, contains the data which were accumulated and the corresponding field strengths are tabulated in Table III. Referring to the graphs, it is seen that the noise-field decreases about 20 decibels when the antenna distance is increased from 100 to 150 feet. This indicates that, where possible, receiving antennas should be located 150 feet or more from automobile traffic arteries. The graphs show that the radiation field from the front of the car is stronger in vertical polarization than it is in horizontal polarization within distances of 100 feet. At distances of from 100 to 150 feet there is little difference shown except in the 90 megacycle vertically-polarized field which is approximately 8 decibels below the average of the others. Such discrepancies are unaccounted for but it is believed that factors such as the size and shape of the car body have a direct bearing on the radiation pattern. The compiled data is included in Appendix I, and typical sections of the recorded charts are included in Appendix II.

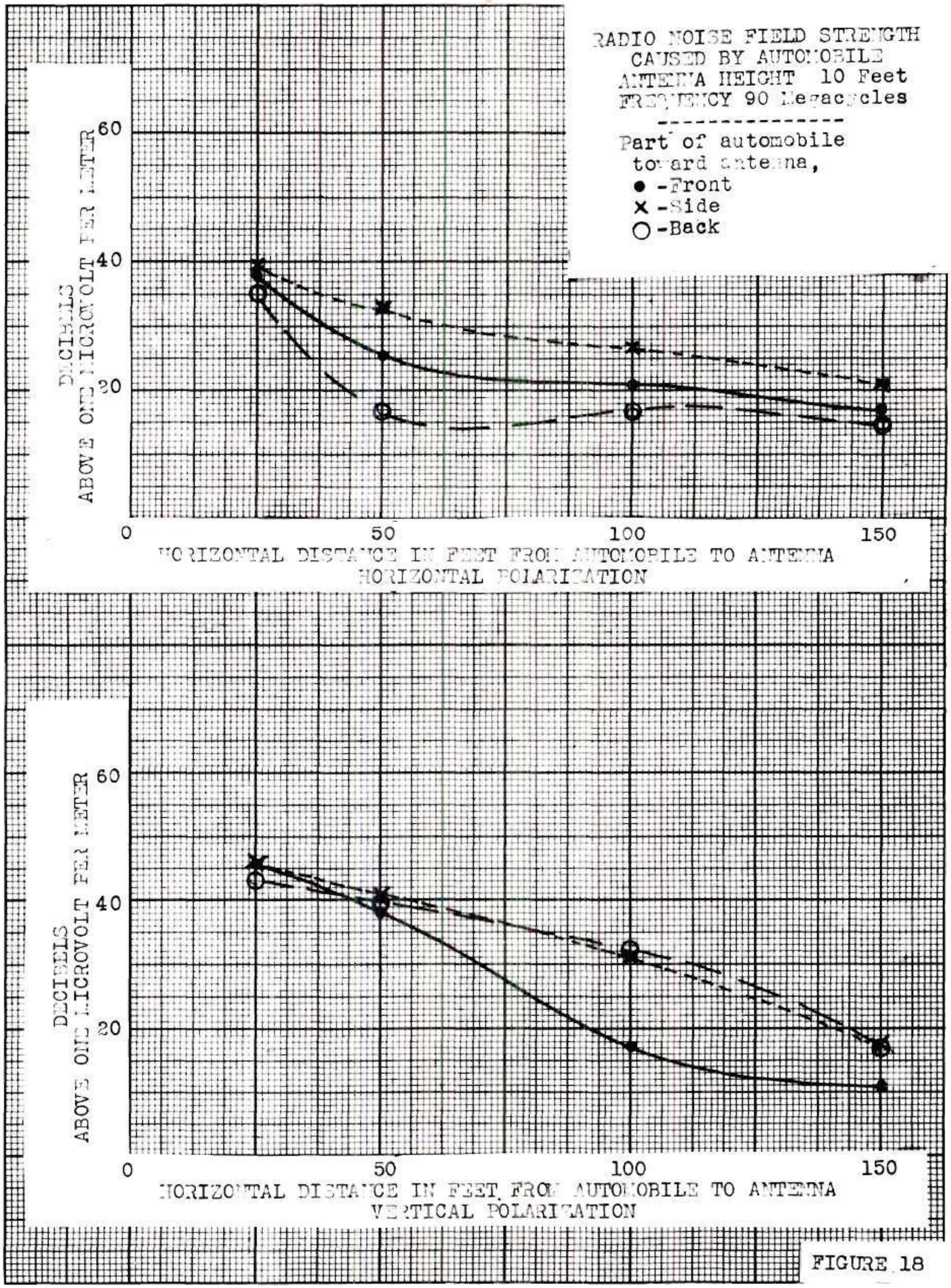

RADIO NOISE FIELD STRENGTH
CAUSED BY AUTOMOBILE
ANTENNA HEIGHT 10 Feet
FREQUENCY 90 Megacycles
Part of automobile
toward antenna,
● -Front
✕ -Side
○ -Back
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
50
100
150
HORIZONTAL DISTANCE IN FEET FROM AUTOMOBILE TO ANTENNA
HORIZONTAL POLARIZATION
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
50
100
150
HORIZONTAL DISTANCE IN FEET FROM AUTOMOBILE TO ANTENNA
VERTICAL POLARIZATION

FIGURE 18

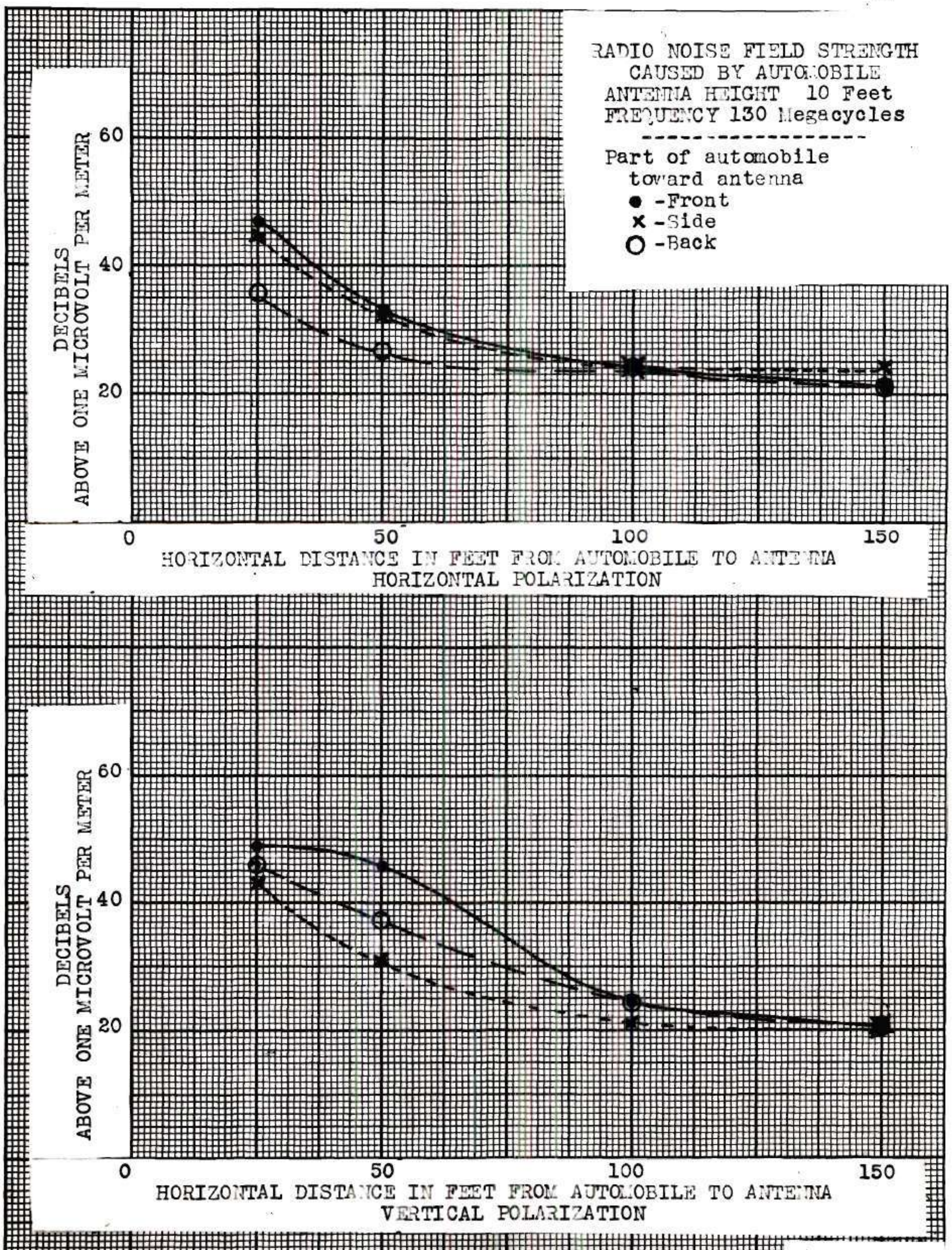

RADIO NOISE FIELD STRENGTH
CAUSED BY AUTOMOBILE
ANTENNA HEIGHT 10 Feet
FREQUENCY 130 Megacycles
Part of automobile
toward antenna
● -Front
× -Side
○ -Back
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
50
100
150
HORIZONTAL DISTANCE IN FEET FROM AUTOMOBILE TO ANTENNA
HORIZONTAL POLARIZATION
DECIBELS
ABOVE ONE MICROVOLT PER METER
60
40
20
0
50
100
150
HORIZONTAL DISTANCE IN FEET FROM AUTOMOBILE TO ANTENNA
VERTICAL POLARIZATION

FIGURE 19

CONCLUSIONS

Additional measurements were made which have not been included in this report. Those which have been included are typical of the area surveyed. It has been definitely established that radio noise, on the frequencies tested, is of local nature. The noise fields at some locations, such as locations 13, 14, 15, and 16 shown on the map, page 40, were too weak to give indications on the meter, while at other places the noise was 60 decibels above 1 microvolt per meter peak value. The measurements were made between the hours of noon and 5 P. M. during the months of February and March, and radio noises due to atmospherics were noticed only one time. This noise, due to atmospherics, was very weak and seemed to have peaks of approximately 5 decibels above 1 microvolt per meter. This work shows that the noise field is high near heavy automobile traffic and that the field weakens rapidly as the distance from the antenna to the traffic lane is increased.

An attempt to correlate the data into actual operational experiences was made. The engineers in charge of the various services operating near the frequencies at which the noise measurements were made furnished such information as they had available. For instance, the engineer for a taxi company pointed out that the noise level in the down-town section was so high that it "opened" the squelch-circuit of their receivers, and that it was necessary to lower the sensitivity of these circuits. Since the transmitter is located in this section too, there is sufficient signal for satisfactory reception. Another taxi company radio engineer reports that the noise from 4 P. M. to 6 P. M. causes reception at their dispatching office to be poor. A utility company communications engineer said, "Signals from our locations away from town are comparatively weak, and noise does interfere with reception from these places."

It should be noted here that all of these services use the narrow-band frequency-modulation system, which is inherently insensitive to the amplitude of radio-frequency noise.

The magnitude of noises recorded in many of the locations would cause serious interference to television services which are expected to be in operation in this area before the year is out.[19]

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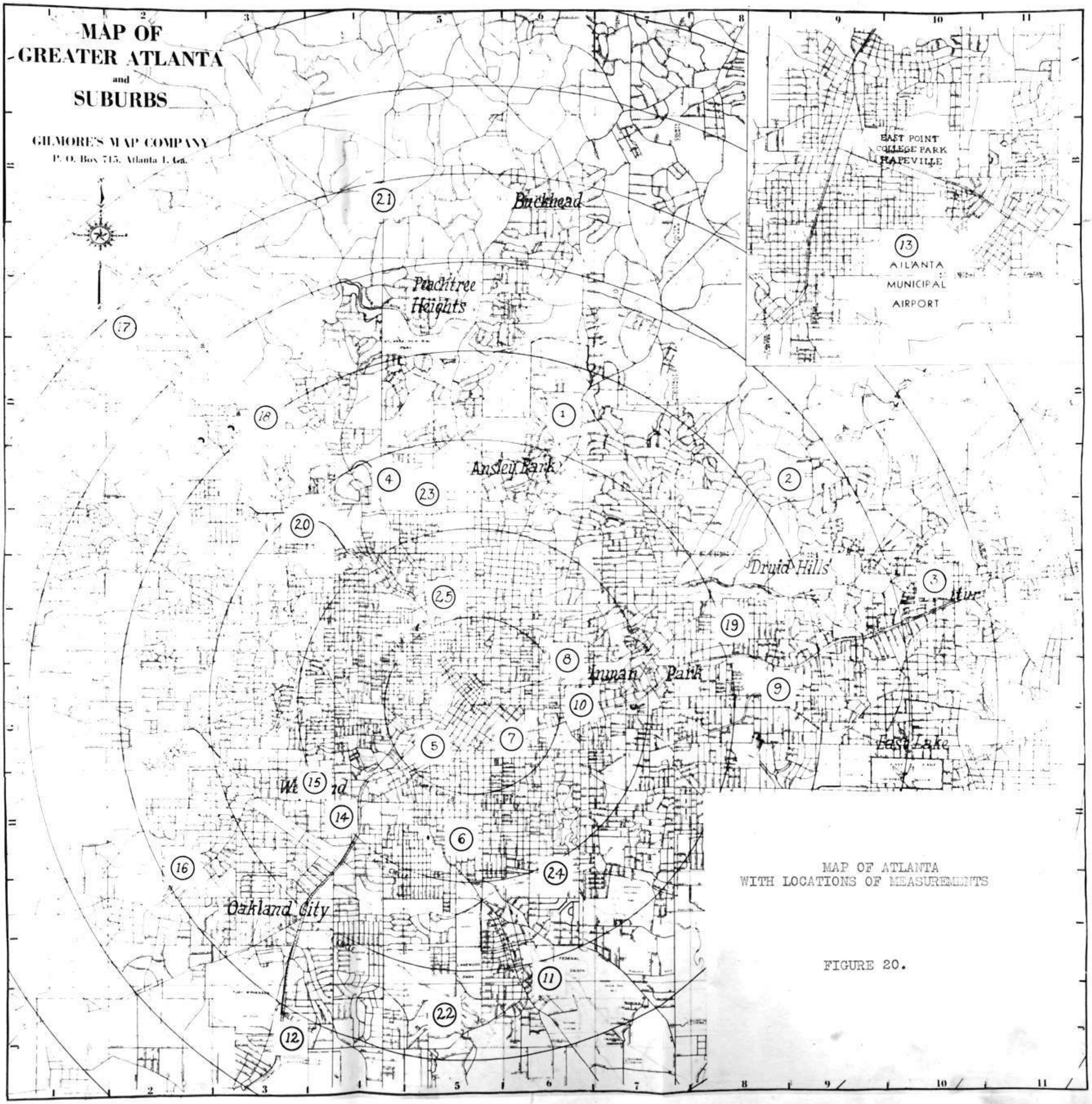
[19] V. K. Zworkin and G. A. Morton, Television (New York, 1940), p. 477.



MAP OF ATLANTA
WITH LOCATIONS OF MEASUREMENTS

FIGURE 20.

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APPENDIX I

TABLES

TABLE I

DATA FOR CONVERTING CHART READINGS TO NOISE-FIELD STRENGTH

Chart-Milliamperes	Field-Strength Meter-Microvolts	Noise field in microvolts per meter at frequency of 90 megacycles/second		Noise field in microvolts per meter at frequency of 130 megacycles/second	
		Cal. Sens. = 1	Cal. Sens. = 2	Cal. Sens. = 1	Cal. Sens. = 2
0.3	3.	5.5	2.7	16.7	8.3
0.5	5.	9.2	4.6	27.8	13.9
1.0	12.	22.2	11.1	66.7	33.3
2.0	26.	48.0	24.0	144.0	72.0
3.0	45.	82.4	41.2	250.0	125.0
4.0	74.	137.0	68.5	410.0	205.0
4.6	100.	185.0	92.5	555.0	277.5

TABLE II

TEST DATA

RECORDED NOISE FIELDS DUE TO ONE AUTOMOBILE

Distance Antenna to Car - Feet	Horizontal polarization: Part of Car toward Antenna			Vertical Polarization: Part of Car toward Antenna		
	Front	Side	Back	Front	Side	Back
25	45.	50.	30.	100.	95.	80.
50	10.	25.	4.	45.	55.	50.
100	6.	12.	4.	4.	20.	25.
150	4.	6.	3.	2.	4.	4.

Meter Indication Due to One Automobile at
Frequency of 130 Megacycles/Second

25	40.	30.	12.	50.	25.	35.
50	8.	7.	4.	35.	6.	14.
100	3.	3.	3.	6.	2.	3.
150	2.	3.	2.	2.	2.	2.

TABLE III

NOISE-FIELD STRENGTH DUE TO ONE AUTOMOBILE

Decibels above 1 microvolt/meter peak

90 Megacycles/Second

	Horizontal Polarization			Vertical Polarization		
Distance Antenna to Car - Feet	Part of Car toward Antenna			Part of Car toward Antenna		
	Front	Side	Back	Front	Side	Back
25	38.6	39.3	34.9	45.3	45.0	43.4
50	25.4	33.1	17.3	38.4	40.2	39.3
100	20.9	26.9	17.3	17.3	31.3	33.3
150	17.3	20.9	15.0	11.2	17.3	17.3

130 Megacycles/Second

25	47.0	44.5	36.5	48.9	43.0	46.0
50	33.0	31.9	26.9	46.0	30.5	37.8
100	24.4	24.4	24.4	24.4	20.9	24.4
150	20.9	24.4	20.9	20.9	20.9	20.9

TABLE IV

DATA CALCULATED FROM CHART MADE AT LOCATION 1.

90-Megacycles. Horizontal-Polarization.
Calibration sensitivity 2. Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
16.2	---	100.0	---	---
6.0	0.3	37.0	2.7	8.6
4.0	0.5	24.6	4.6	13.3
3.5	1.0	21.5	11.1	20.9
2.7	2.0	17.0	24.0	27.6
2.0	3.0	12.3	41.2	32.3
0.8	4.0	5.0	68.5	36.7
0.4	4.6	2.8	92.5	39.3

90-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

14.6	---	100.0	---	---
8.5	0.3	58.2	5.5	14.8
4.2	0.5	28.7	9.2	19.3
3.6	1.0	27.6	22.2	26.9
2.6	2.0	18.0	48.0	33.6
2.0	3.0	14.0	82.4	38.3
1.4	4.0	9.5	137.0	42.7
0.8	4.6	5.4	185.0	45.4

130-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

20.9	---	100.0	---	---
4.0	0.3	19.0	16.7	24.5
2.2	0.5	10.5	27.8	28.9
1.3	1.0	6.2	66.7	36.5
0.6	2.0	3.0	144.0	43.2
0.2	3.0	2.0	250.0	48.0
0.1	4.0	0.5	410.0	52.3
0.1-	4.6	0.1	555.0	54.9

130-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

17.2	---	100.0	---	---
2.2	0.3	13.0	16.7	24.5
1.2	0.5	7.0	27.8	28.9
0.6	1.0	3.5	66.7	36.5
0.4	2.0	2.3	144.0	43.2
0.2	3.0	1.2	250.0	48.0
0.1	4.0	0.6	410.0	52.3
0.1-	4.6	0.1	555.0	54.9

TABLE V

DATA CALCULATED FROM CHART MADE AT LOCATION 2.

90-Megacycles.
Calibration sensitivity 2.

Horizontal-Polarization.
Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
18.5	--	100.0	--	--
3.3	0.3	18.4	5.5	14.8
3.0	0.5	16.2	9.2	19.3
2.5	1.0	13.5	22.2	26.9
1.0	2.0	5.4	48.0	33.6
0.4	3.0	2.2	82.4	38.3
0.3	4.0	1.6	137.0	42.7
0.1	4.6	0.5	185.0	45.4

90-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

20.1	--	100.0	--	--
6.0	0.3	29.9	5.5	14.8
5.3	0.5	26.4	9.2	19.3
4.0	1.0	20.0	22.2	26.9
1.5	2.0	7.5	48.0	33.6
0.9	3.0	4.5	82.4	38.3
0.3	4.0	1.5	137.0	42.7
0.2	4.6	1.0	185.0	45.4

130-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization.
Attenuator constant 1.

12.9	--	100.0	--	--
1.3	0.3	10.1	16.7	24.5
1.1	0.5	8.5	27.8	28.9
0.9	1.0	7.0	66.7	36.5
0.5	2.3	3.9	144.0	43.2
0.2	3.0	1.5	250.0	48.0
0.0	4.0	0.0	0.0	0.0

130-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

22.2	--	100.0	--	--
2.5	0.3	11.3	16.7	24.5
2.0	0.5	9.0	27.8	28.9
1.3	1.0	5.8	66.7	36.5
0.6	2.0	2.7	144.0	43.2
0.4	3.0	1.8	250.0	48.0
0.1	4.0	0.4	410.0	52.3
0.1-	4.6	0.1	555.0	54.9

TABLE VI

DATA CALCULATED FROM CHART MADE AT LOCATION 3.

90-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 10.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
29.1	--	100.0	--	--
8.7	0.3	30.6	55.0	34.8
7.1	0.5	24.4	92.0	39.3
4.6	1.0	15.8	222.0	46.9
2.2	2.0	7.5	480.0	53.6
1.0	3.0	3.4	824.0	58.3
0.4	4.0	1.4	1370.0	62.7
0.2	4.6	0.7	1850.0	65.4

90-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 10.

29.6	--	100.0	--	--
10.9	0.3	37.2	55.0	34.8
8.7	0.5	29.4	92.0	39.3
6.8	1.0	23.0	222.0	46.9
2.4	2.0	8.1	480.0	53.6
0.9	3.0	3.1	824.0	58.3
0.3	4.0	1.0	1370.0	62.7
0.1	4.6	0.3	1850.0	65.4

130-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

25.4	--	100.0	--	--
25.0	0.3	98.5	16.7	24.5
24.4	0.5	96.0	27.8	28.9
21.0	1.0	82.6	66.7	26.5
12.0	2.0	47.2	144.0	43.2
5.9	3.0	23.2	250.0	48.0
2.0	4.0	7.8	410.0	52.3
1.0	4.6	4.0	555.0	54.9

130-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

28.5	--	100.0	--	--
28.2	0.3	99.0	16.7	24.5
28.1	0.5	98.5	27.8	28.9
26.0	1.0	91.0	66.7	36.5
14.0	2.0	49.0	144.0	43.2
5.7	3.0	20.0	250.0	48.0
1.6	4.0	5.7	410.0	52.3
0.6	4.6	2.1	555.0	54.9

TABLE VII

DATA CALCULATED FROM CHART MADE AT LOCATION 4.

90-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization.
Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
23.8	—	100.0	—	—
23.8	0.3	100.0	5.5	14.8
23.0	0.5	96.5	9.2	19.3
16.8	1.0	70.5	22.2	26.9
7.0	2.0	29.4	48.0	33.6
3.1	3.0	13.0	82.4	38.3
1.3	4.0	1.3	137.0	42.7
0.4	4.6	1.7	185.0	45.4

90-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

26.9	—	100.0	—	—
26.4	0.3	98.1	5.5	14.8
26.3	0.5	97.6	9.2	19.3
24.3	1.0	90.2	22.2	26.9
9.4	2.0	35.2	48.0	33.6
4.7	3.0	17.5	82.4	38.3
2.2	4.0	8.2	137.0	42.7
1.4	4.6	5.2	185.0	45.4

130-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization
Attenuator constant 1.

24.5	—	100.0	—	—
24.5	0.3	99.0	16.7	24.5
24.3	0.5	98.0	27.8	28.9
24.1	1.0	95.0	66.7	36.5
14.5	2.0	59.2	144.0	43.2
1.0	3.0	4.1	250.0	48.0
0.2	4.0	0.8	410.0	52.3
0.1	4.6	0.4	555.0	54.9

130-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

23.0	—	100.0	—	—
19.6	0.3	81.7	16.7	24.5
14.0	0.5	57.3	27.8	28.9
8.2	1.0	34.1	66.7	36.5
1.3	2.0	5.4	144.0	43.2
0.2	3.0	0.8	250.0	48.0

TABLE VIII

DATA CALCULATED FROM CHART MADE AT LOCATION 5.

90-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
19.7	--	100.0	--	--
18.1	0.3	91.9	5.5	14.8
17.9	0.5	90.9	9.2	19.3
15.1	1.0	76.7	22.2	26.9
6.5	2.0	33.0	48.0	33.6
3.5	3.0	17.8	82.4	38.3
2.4	4.0	12.2	137.0	42.7
1.2	4.6	6.1	185.0	45.4

90-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

24.5	--	100.0	--	--
11.0	0.3	44.9	5.5	14.8
9.1	0.5	37.2	9.2	19.3
6.0	1.0	24.5	22.2	26.9
3.4	2.0	13.9	48.2	33.6
2.1	3.0	8.6	82.4	38.3
0.8	4.0	3.3	137.0	42.7
0.6	4.6	2.4	185.0	45.4

130-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

18.0	--	100.0	--	--
9.1	0.3	50.5	16.7	24.5
8.8	0.5	48.9	27.8	28.9
6.0	1.0	33.4	66.7	36.5
2.8	2.0	15.6	144.0	43.2
1.5	3.0	8.3	250.0	48.0
0.8	4.0	4.4	410.0	52.3
0.3	4.6	1.6	555.0	54.9

130-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

21.5	--	100.0	--	--
16.7	0.3	77.6	16.7	24.5
15.6	0.5	72.5	27.8	28.9
12.7	1.0	59.2	66.7	36.5
9.4	2.0	43.7	144.0	43.2
6.0	3.0	27.9	250.0	48.0
3.0	4.0	14.0	410.0	52.3
1.5	4.6	7.0	555.0	54.9

TABLE IX

DATA CALCULATED FROM CHART MADE AT LOCATION 6.

90-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuation constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
24.2	--	100.0	--	--
22.0	0.3	92.5	5.5	14.8
21.5	0.5	86.5	9.2	19.3
6.0	1.0	61.2	22.2	26.9
2.8	2.0	13.1	48.0	33.6
1.6	3.0	9.0	82.4	38.3
1.0	4.0	4.1	137.0	42.7
0.7	4.6	3.4	185.0	45.4

90-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

26.8	--	100.0	--	--
24.8	0.3	92.5	5.5	14.8
23.2	0.5	86.5	9.2	19.3
16.4	1.0	61.2	22.2	26.9
3.5	2.0	13.1	48.0	33.6
2.4	3.0	9.0	82.4	38.3
1.1	4.0	4.1	137.0	42.7
0.9	4.6	3.4	185.0	45.4

130-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

19.0	--	100.0	--	--
10.5	0.3	51.3	16.7	24.5
6.0	0.5	31.6	27.8	28.9
3.2	1.0	16.8	66.0	36.5
1.6	2.0	8.4	144.0	43.2
0.9	3.0	4.7	250.0	48.0
0.5	4.0	2.6	410.0	52.3
0.2	4.6	1.0	555.0	54.9

130-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

17.5	--	100.0	--	--
2.4	0.3	13.7	16.7	24.5
2.0	0.5	11.4	27.8	28.9
1.0	1.0	5.7	66.1	36.5
0.5	2.0	2.8	144.0	43.2
0.4	3.0	2.3	250.0	48.0
0.2	4.0	1.1	410.0	52.3
0.1	4.6	0.6	555.0	54.9

TABLE X

DATA CALCULATED FROM CHART MADE AT LOCATION 7.

90-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
20.0	---	100.0	---	---
20.0	0.3	100.0	5.5	14.8
20.0	0.5	100.0	9.2	19.3
19.4	1.0	97.0	22.2	26.9
6.5	2.0	32.5	48.0	33.6
3.5	3.0	17.5	82.4	38.3
1.4	4.0	7.0	137.0	42.7
0.6	4.6	3.0	185.0	45.4

90-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

18.5	---	100.0	---	---
18.5	0.3	100.0	5.5	14.8
18.5	0.5	100.0	9.2	19.3
18.5	1.0	100.0	22.2	26.9
18.5	2.0	100.0	48.0	33.6
8.2	3.0	44.4	82.4	38.3
3.3	4.0	17.9	137.0	42.7
1.5	4.6	8.1	185.0	45.4

130-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

19.5	---	100.0	---	---
2.6	0.3	13.3	16.7	24.5
1.9	0.5	9.7	27.8	28.9
1.0	1.0	5.1	66.1	36.5
0.6	2.0	3.1	144.0	43.2
0.1	3.0	0.5	250.0	48.0

130-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

23.5	---	100.0	---	---
1.6	0.3	6.8	16.7	24.5
1.2	0.5	5.1	27.8	28.9
0.3	1.0	1.3	66.1	36.5
0.1	2.0	0.4	144.0	43.2

TABLE XI

DATA CALCULATED FROM CHART MADE AT LOCATION 8.

90-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
26.0	---	100.0	---	---
19.4	0.3	74.7	5.5	14.8
15.2	0.5	58.5	9.2	19.3
11.2	1.0	43.0	22.2	26.9
4.0	2.0	15.4	48.0	33.6
2.0	3.0	7.7	82.4	38.3
0.8	4.0	3.1	137.0	42.7
0.3	4.6	1.1	185.0	45.4

90-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

26.6	---	100.0	---	---
24.5	0.3	92.2	5.5	14.8
18.0	0.5	67.7	9.2	19.3
11.2	1.0	42.2	22.2	26.9
5.0	2.0	18.8	48.0	33.6
3.0	3.0	11.3	82.4	38.3
1.7	4.0	6.4	137.0	42.7
1.1	4.6	4.1	185.0	45.4

130-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

22.6	---	100.0	---	---
21.7	0.3	96.0	16.7	24.5
7.2	0.5	31.8	27.8	28.9
1.5	1.0	6.6	66.7	36.5
0.4	2.0	0.9	144.0	43.2
0.2	3.0	0.4	250.0	48.0
0.1	4.0	0.1	410.0	52.3
0.1-	4.6	0.1-	555.0	54.9

130-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

26.0	---	100.0	---	---
16.0	0.3	61.5	16.7	24.5
15.0	0.5	57.7	27.8	28.9
10.6	1.0	40.8	66.7	36.5
3.0	2.0	11.5	144.0	43.2
0.2	3.0	0.7	250.0	48.0
0.1-	4.0	0.1	410.0	52.3

TABLE XII

DATA CALCULATED FROM CHART MADE AT LOCATION 9.

90-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization.
Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
27.7	---	100.0	---	---
2.6	0.3	9.3	5.5	14.8
2.4	0.5	8.6	9.2	10.3
2.1	1.0	7.5	22.2	26.9
0.8	2.0	2.9	48.0	33.6
0.3	3.0	1.1	82.4	38.3
0.1	4.0	0.4	137.0	42.7
0.1-	4.6	0.1	185.0	45.4

90-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

22.0	---	100.0	---	---
9.0	0.3	41.0	5.5	14.8
6.5	0.5	29.4	9.2	19.3
5.0	1.0	22.7	22.2	26.9
2.6	2.0	11.8	48.0	33.6
1.1	3.0	5.0	82.4	38.3
0.5	4.0	2.2	137.0	42.7
0.3	4.6	1.3	185.0	45.4

130-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization.
Attenuator constant 1.

21.5	---	100.0	---	---
4.6	0.3	21.4	16.7	24.5
4.0	0.5	18.6	27.8	28.9
3.0	1.0	14.0	66.1	36.5
0.7	2.0	3.3	144.0	43.2
0.2	3.0	0.9	250.0	48.0

130-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

30.0	---	100.0	---	---
9.0	0.3	30.0	16.7	24.5
7.1	0.5	23.3	27.8	28.9
3.2	1.0	11.6	66.1	36.5
0.6	2.0	2.0	144.0	43.2
0.1	3.0	0.3	250.0	48.0
0.1-	4.0	0.1	410.0	52.3
0.1-	4.6	0.1-	555.0	54.9

TABLE XIII

DATA CALCULATED FROM CHART MADE AT LOCATION 10.

90-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
19.8	--	100.0	--	--
7.2	0.3	36.4	5.5	14.8
6.0	0.5	30.3	9.2	19.3
3.9	1.0	19.6	22.2	26.9
3.0	2.0	15.1	48.0	33.6
2.2	3.0	11.1	82.4	38.3
1.5	4.0	7.5	137.0	42.7
1.0	4.6	5.5	185.0	45.4

90-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

18.4	--	100.0	--	--
6.8	0.3	37.0	5.5	14.8
6.4	0.5	34.7	9.2	19.3
5.0	1.0	27.2	22.2	26.9
3.7	2.0	20.1	48.0	33.6
2.5	3.0	13.6	82.4	38.3
1.6	4.0	8.7	137.0	42.7
1.1	4.6	6.0	185.0	45.4

130-Megacycles. Horizontal-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

8.1	--	100.0	--	--
6.0	0.3	74.0	16.7	24.5
5.0	0.5	61.7	27.8	28.9
3.5	1.0	43.2	66.7	36.5
1.0	2.0	12.3	144.0	43.2
0.3	3.0	3.7	250.0	48.0
0.1	4.0	0.1	410.0	52.3
0.1-	4.6	0.1-	555.0	54.9

130-Megacycles. Vertical-Polarization.
Calibration sensitivity 1. Attenuator constant 1.

12.5	--	100.0	--	--
12.2	0.3	97.5	16.7	24.5
10.8	0.5	86.4	27.8	28.9
7.5	1.0	60.0	66.7	36.5
2.5	2.0	20.0	144.0	43.2
0.7	3.0	5.7	250.0	48.0
0.3	4.0	2.4	410.0	52.3
0.1	4.6	0.8	555.0	54.9

TABLE XIV

DATA CALCULATED FROM CHART MADE AT LOCATION 11.

90-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization.
Attenuator constant 1.

Inches of chart	Chart inked above this value of milliamperes	Time in per cent	Microvolts peak value	Decibels above 1 microvolt
26.0	--	100.0	--	--
10.0	0.3	38.5	5.5	14.8
5.3	0.5	20.4	9.2	19.3
4.0	1.0	15.4	22.2	26.9
3.0	2.0	11.5	48.0	33.6
2.3	3.0	8.8	82.4	38.3
1.1	4.0	4.2	137.0	42.7
0.9	4.6	3.5	185.0	45.4

90-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

25.1	--	100.0	--	--
2.0	0.3	8.0	5.5	14.8
1.0	0.5	4.0	9.2	19.3
0.6	1.0	2.4	22.2	26.9
0.4	2.0	1.6	48.0	33.6
0.1	3.0	0.4	82.4	38.3
0.1	4.0	0.1	137.0	42.7
0.1-	4.6	0.1-	185.0	45.4

130-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization.
Attenuator constant 1.

27.3	--	100.0	--	--
8.0	0.3	29.4	16.7	24.5
7.0	0.5	25.6	27.8	28.9
4.6	1.0	16.9	66.7	36.5
2.5	2.0	9.2	144.0	43.2
1.8	3.0	6.6	250.0	48.0
0.8	4.0	2.9	410.0	52.3
0.2	4.6	0.7	555.0	54.9

130-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

23.2	--	100.0	--	--
5.2	0.3	22.4	16.7	24.5
4.6	0.5	19.8	27.8	28.9
3.5	1.0	15.1	66.7	36.5
2.0	2.0	8.6	144.0	43.2
1.4	3.0	6.1	250.0	48.0
0.5	4.0	2.1	410.0	52.3
0.2	4.6	0.8	555.0	54.9

TABLE XV

DATA CALCULATED FROM CHART MADE AT LOCATION 12.

90-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization.
Attenuator constant 1.

Number of pulses	Pulses above this value of milliamperes	Pulses in per cent of total	Microvolts peak value	Decibels above 1 microvolt
28	--	100.0	-- --	--
20	0.3	71.5	5.5	14.8
17	0.5	60.7	0.2	19.3
6	1.0	21.4	22.2	26.9
3	2.0	10.7	48.0	33.6

90-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

Number of pulses	Pulses above this value of milliamperes	Pulses in per cent of total	Microvolts peak value	Decibels above 1 microvolt
74	--	100.0	--	--
52	0.3	70.4	5.5	14.8
42	0.5	56.8	9.2	19.3
26	1.0	35.2	22.2	26.9
7	2.0	9.4	48.0	33.6
1	3.0	1.3	82.4	38.3

130-Megacycles.
Calibration sensitivity 1.

Horizontal-Polarization.
Attenuator constant 1.

Number of pulses	Pulses above this value of milliamperes	Pulses in per cent of total	Microvolts peak value	Decibels above 1 microvolt
121	--	100.0	--	--
92	0.3	76.0	16.7	24.5
75	0.5	62.0	27.8	28.9
47	1.0	38.8	66.7	36.5
8	2.0	6.6	144.0	43.2
1	3.0	0.8	250.0	48.0

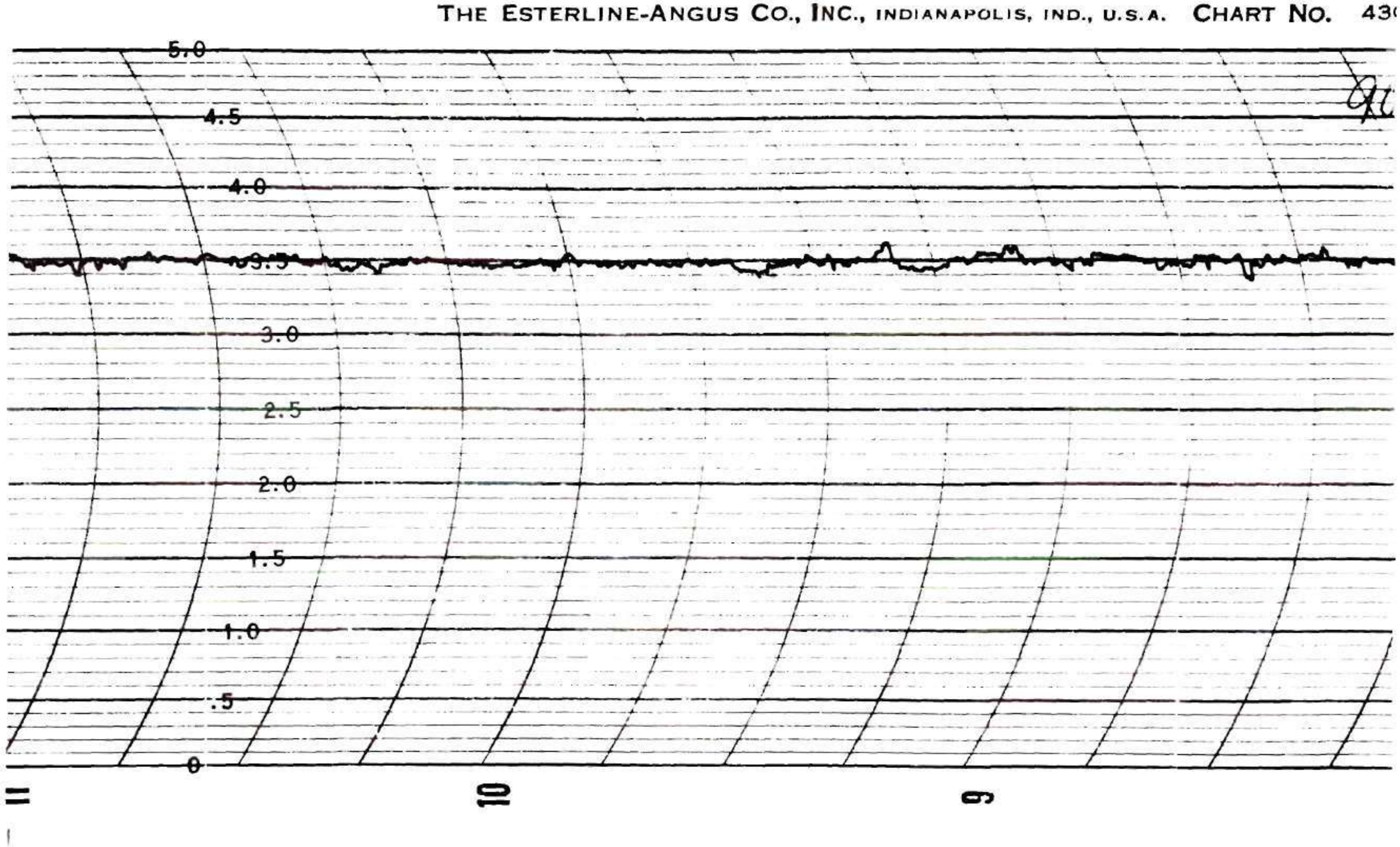
130-Megacycles.
Calibration sensitivity 1.

Vertical-Polarization.
Attenuator constant 1.

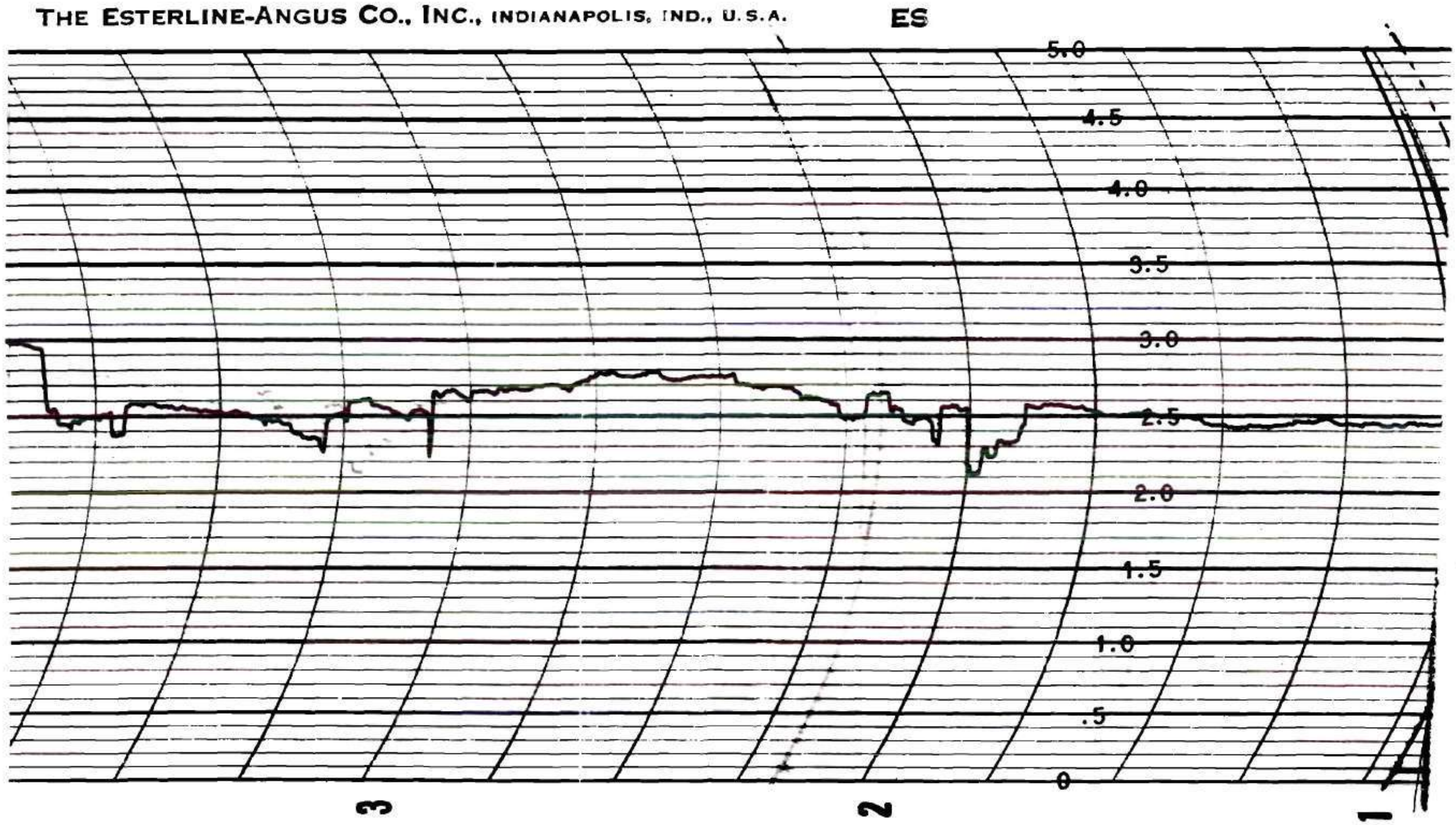
Number of pulses	Pulses above this value of milliamperes	Pulses in per cent of total	Microvolts peak value	Decibels above 1 microvolt
114	--	100.0	--	--
81	0.3	71.0	16.7	24.5
74	0.5	64.9	27.8	28.9
41	1.0	36.0	66.7	36.5
7	2.0	6.1	144.0	43.2
2	3.0	1.8	250.0	48.0

APPENDIX II

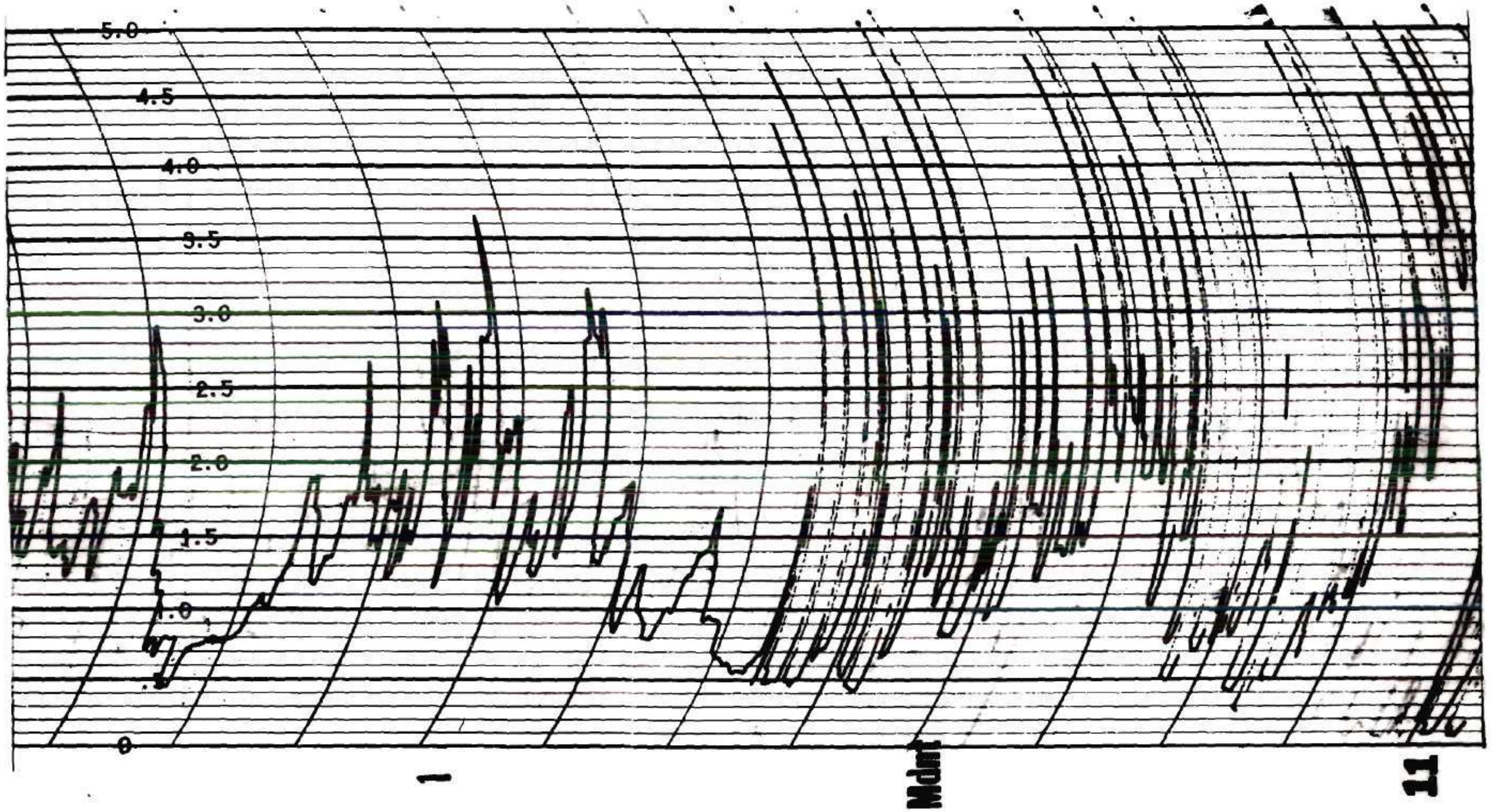
CHARTS



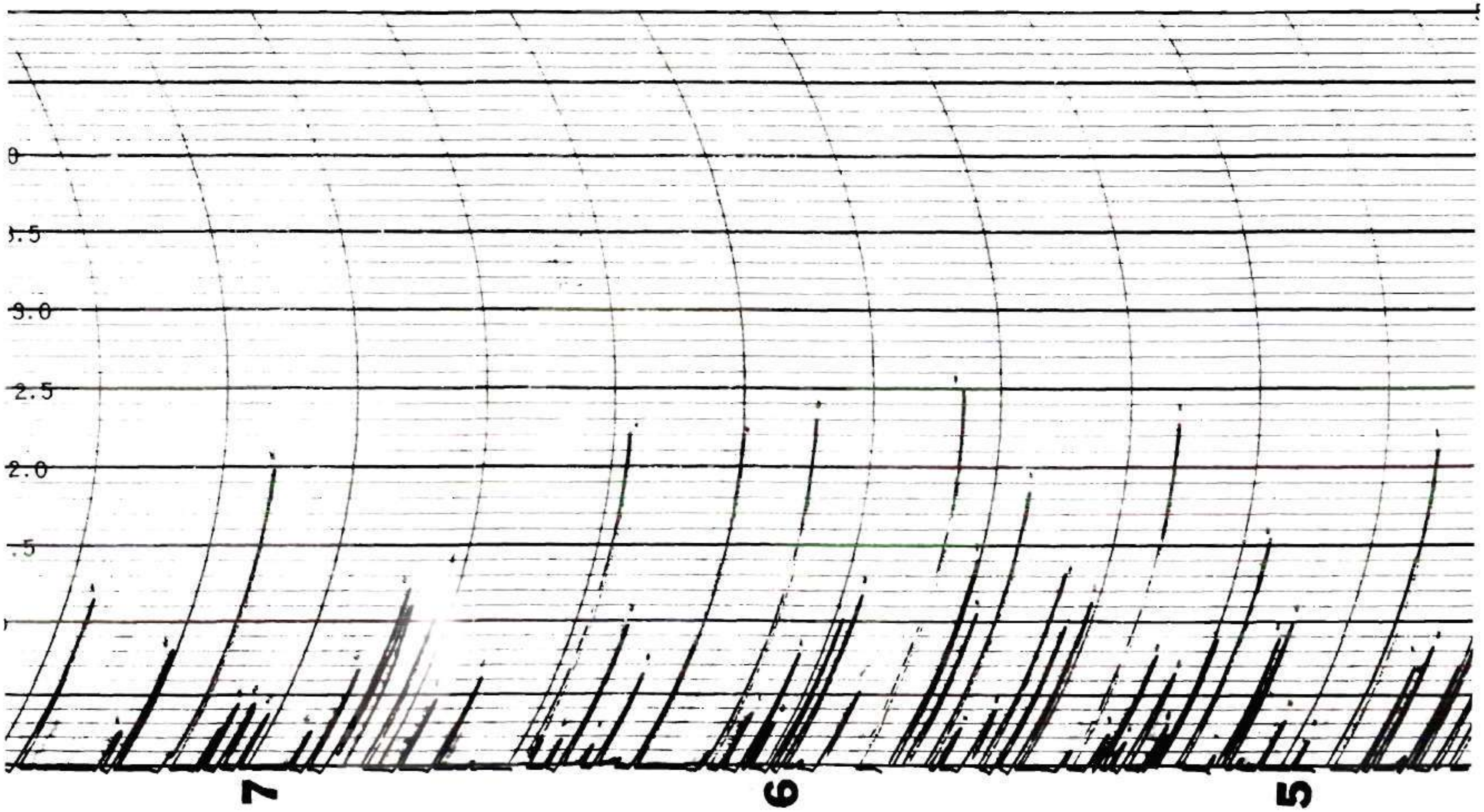
A SECTION OF THE CHART RECORDED AT LOCATION 23



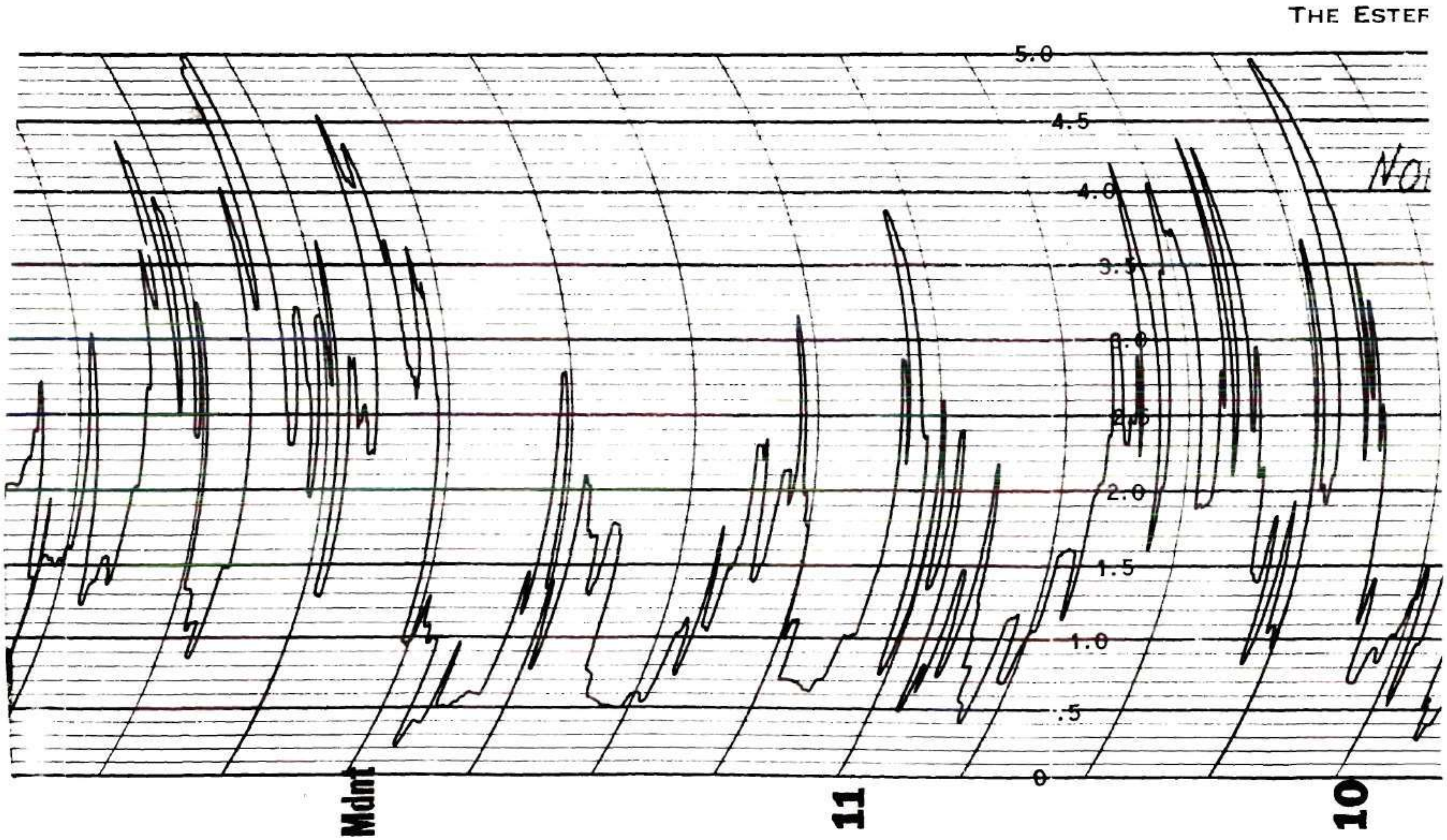
A SECTION OF THE CHART RECORDED AT LOCATION 24



A SECTION OF THE CHART RECORDED AT LOCATION 10



A SECTION OF THE CHART RECORDED AT LOCATION 12



A SECTION OF THE CHART RECORDED AT LOCATION 4